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The Seventy-Fifth Meeting of the American Astronomical Society

By C. M. HUFFER

The 75th meeting of the American Astronomical Society was held at the Washburn Observatory and the University of Wisconsin on the invitation of Dr. Joel Stebbins. At the 74th meeting the President of the Society had expressed the hope that the 75th would be held at a mid-western observatory, such as the one at Madison. Naturally the invitation was promptly forthcoming, although plans for a meeting in Madison had been gradually forming for a later date.

The dates of September 8 to 11 were set after it became certain that the men's dormitories on Lake Mendota would be available, although it was known that dates after the opening of the public schools would make it impossible for some parents to be away from home at that time.

The weather, always an important factor, co-operated beautifully. There were two nights when rain fell, but at a time when even astronomers were glad to be asleep. The sky was cloudy on the evening of the open house at the Observatory, but the light of a flash-light was used instead of a star to show how actual observations could be made. A boat ride that afternoon had been successful in spite of threatening rain.

The first arrivals came on the trains Sunday noon. Those who had not dined on the train were hurried to the Wisconsin Union for dinner. The others were taken to the dormitories where registration procedure had been set up. The unfortunate members of the Council, including the writer of this report—by invitation, since he had to learn the complicated business of being Secretary—started the official business of the Society by meeting at 4 P.M., adjourning to Tripp Commons in the Union for supper, and continuing in the Observatory until it became absolutely necessary to adjourn for the reception.

Beginning at 8 o'clock, the Observatory Residence just east of the Observatory was thronged with astronomers and their wives and a few children. President Fred of the University of Wisconsin was in the receiving line with the host, Dr. Stebbins, and the President of the Society, Dr. Shapley. Mrs. Stebbins, with the help of Mrs. Fred and several faculty wives, served ice cream, cake, and coffee. Music was provided informally by the new Secretary and his son with Mozart violin sonatas, by Professors Minnaert and Van de Kamp with piano

selections, and Dr. Goldberg with vocal numbers from Gilbert and Sullivan.

The opening session of the Society was set for 9 A.M. Monday. This session, as were all other sessions, was held in the Play Circle of the Wisconsin Union. This room is used as a movie theater on week-ends and for student play productions at other times, but made an excellent room for a scientific meeting. It is small, intimate, and comfortable and even the faintest-voiced speaker could be heard with ease. President Fred welcomed the Society, described the relationship between the Washburn Observatory, the University, and astronomy and invited the Society to return to Madison in two years to help the University celebrate its 100th anniversary.

Then followed the serious business of presentation of papers. There were five sessions for papers and one conference for teachers. About forty papers were presented, including two or three not on the printed program. They were arranged, as usual, in groups according to subject. The press notices played up two papers having to do with rockets and space travel. There were others in the fields of fundamental astronomy, eclipsing stars, spectroscopy, photoelectric observations, and theoretical astrophysics. But since the abstracts will all be published by the Society, this is not the place to attempt to discuss their contents.

The annual meeting and election of officers was held on Tuesday afternoon. A list of members deceased since the last business meeting was read, and the names of members newly elected by the Council were read by the Secretary.

The results of the election, after some delay in finding the tellers, were given as follows:

President	1946-49	Otto Struve
Vice-President	1946-48	Donald H. Menzel
Secretary	1946-47	C. M. Huffer
Treasurer	1946-47	J. J. Nassau
Councilors	1946-49	H. L. Alden
		Ida Barney
		O. C. Wilson

A nominating committee to select the candidates for next year's election was chosen by three nominations and unanimous election. The committee is composed of:

Dean B. McLaughlin
Albert E. Whitford
Frank S. Hogg

all of whom were present at the meeting.

A vote of thanks by acclamation was given Dr. Keivin Burns for his five years of service to the Society as Treasurer. Dr. Burns took office after the tragic death of Dr. Jordan when the financial affairs of the Society were in a very difficult state and with his own hands brought them into the present excellent condition. He stated that he

was retiring as Treasurer because he felt that the affairs of the Society should be in the hands of younger men.

The social arrangements of the 75th meeting should be mentioned especially. We have already described briefly the reception on Sunday evening and have mentioned that the men's dormitories were used to house the guests. In making room assignments, it was found desirable to separate husbands and wives to equalize the wash-room space. However, as soon as the husbands and wives found out that they were to be separated, they took things into their own hands. "Love will find a way."

On Monday evening the Observatory was open to visiting astronomers and guests. Dr. Whitford demonstrated the new photoelectric multiplier and oscilloscope which he had used so successfully at Mt. Wilson during the summer. Unfortunately the sky was cloudy and he had to show the galvanometer deflections or oscilloscope deviations by flashing a light on the inside of the dome—which light was about the equivalent of an 8th magnitude star. Many astronomers took advantage of the occasion to ask questions. Some went so far as to make drawings of the circuit and apparatus. It reminds one of the policy of the Army during the war. No secrets were revealed until the next development was available—sometimes called "the answer to the answer." Dr. Whitford did not reveal his plans for the next stage of photoelectric development.

Dr. Stebbins had a display of photoelectric cells arranged in historical order. The development of photometers used at the Washburn Observatory and at Mt. Wilson was also shown. In 24 years, since starting photoelectric photometry at Madison, the effective size of the 15.6-inch refractor has been increased by discontinuous changes of the sensitivity of apparatus at the eye-end of the telescope. The change from electrometers to amplifiers to multipliers was dramatically demonstrated. The greatest handicap is the Wisconsin sky which keeps the accuracy of photometric observations made in Madison considerably below those made in the California observatories.

The social climax of the meeting was the special dinner on Tuesday evening. The scene was Tripp Commons of the Wisconsin Union where a semi-cafeteria dinner was served. By semi-cafeteria is meant that each guest carried his plate laden with ham and potatoes and a few accessories to a table where salad and coffee were served by waiters. Then the men were required to go after the apple pie *a la mode* for himself and his lady guests. But there were no complaints about this post-war adjustment and by 8:30 everybody was sufficiently drowsy to listen to after-dinner speeches.

President Shapley was the toastmaster. He first introduced Dr. Stebbins who proposed a vote of thanks in appreciation of the work of Dr. McLaughlin for his seven years as Secretary. McLaughlin replied with

his thanks and was obviously relieved that he could pass on the work of the Society to the new Secretary. Dr. Stebbins then went on to tell of the history of the Washburn Observatory—little-known facts about the Watson solar observatory and the tail of Halley's comet.

The toastmaster then called on Professor Minnaert of Holland. Since Professor Minnaert had spent two years in a German concentration camp, he spoke feelingly of the need of a world union for humanity. He pointed out that we in America should not smugly sit back and tell the Europeans that they should try to get along with each other when we have our own Negro and Jewish problems. All present were deeply impressed.

Mr. Federer told briefly of the relationship between the Society and the Press. It should be mentioned here that the press coverage of this meeting was exceptionally good, thanks to the efforts of Mr. Federer and Mr. Foss of the University Press department.

Dr. Shapley then continued with some communications to the Society, particularly from a young lady in Italy who sent a photograph, which (the photograph, that is) was much sought after by the officers of the Society. He closed the evening by presenting the charter of the Society to the new President who responded very briefly.

At the final session on Wednesday morning, announcement was made of the Christmas meeting to be held at Harvard from December 26 to 30. This meeting is with the American Association for the Advancement of Science and will help celebrate the centennial of the Harvard College Observatory. Four symposia are planned with invited papers and there will be time for a few contributed papers from members of the Society.

The next summer meeting will be held in Evanston in September, 1947. This will mark the 50th anniversary of the meeting at Yerkes Observatory in 1897 when plans were made for the organization of the Society. Since accommodations are not available at Williams Bay, the major portion of the meeting will be held in Evanston with a special trip to Yerkes Observatory.

In his report of the 74th meeting, Dr. McLaughlin concluded with the words: "We ought to go back to three-day meetings." His opinion was substantiated at the 75th. The sessions gave one the impression of freedom from hurry. There was plenty of time for discussion, everything was done that had been planned, and the meeting ended exactly on time.

WASHBURN OBSERVATORY, UNIVERSITY OF WISCONSIN, SEPTEMBER 14, 1946.

The Development of Astronomical Photometry

By HAROLD F. WEAVER

(Continued from page 351)

The Specialized Fields of Photographic Photometry

With the tremendous forward strides made in the general field of photographic photometry during the past fifty years, there have been concurrent advances in all the more specialized fields of astronomical photometry—fields involving the photometry of variable stars, the surface photometry of extended objects such as planets, satellites, comets, nebulae, clusters, and the sky itself, the determination of colors, and so forth. Probably none of these fields has been more active than that of the photographic determination of colors.

The Photographic Determination of Colors

The fact that magnitudes determined from star images on photographic plates differed systematically from those determined by eye was, interestingly enough, cited by some observers during the early days of astronomical photographic photometry as one of the most important reasons for not using the photographic process for photometric purposes. One of the earliest observers to try to change these views and to recognize the importance of photography as a means of determining the colors of the stars as well as their magnitudes was Pickering,[61] who stated: "The photograph furnishes an excellent test of the color of a star, since on comparison with the visual brightness, the stars which are faint photographically may be assumed to be red, and the bright ones blue. As the difference amounts to several magnitudes, it furnishes a test much more sensitive than that of the eye. Again, the method is applicable to the faintest stars visible, when the difference in color is quite imperceptible by any other means."

Somewhat later, in 1900, Schwarzschild[62] made a similar suggestion in regard to the use of the difference between visual and photographic magnitudes as an accurate measure of a star's color, and during the years 1904-1908 Parkhurst and Jordan[63] at the Yerkes Observatory determined star colors, (or "color intensities" as they called them) in that manner. They departed slightly from the procedure outlined by Pickering and Schwarzschild, however, in that they determined both the photo-

[61] *Mem. Am. Acad. of Arts and Sci.*, **11**, 203, 1888.

[62] *Sitz. der K. Akad. der Wiss. in Wien, Math.-Naturwiss. Classe*, **109**, 1127, 1900.

[63] *Science*, **21**, 417, 1905; *Ap. J.*, **27**, 169, 1908.

graphic magnitudes and the "visual magnitudes" involved in the color intensities by photography, the "visual magnitudes" being determined with the aid of orthochromatic plates in combination with a yellow filter. Parkhurst and Jordan thus became, apparently, the first observers to determine star colors entirely by photographic means.

In 1916 Seares described his exposure-ratio method of determining star colors which did not involve setting up two independent magnitude scales as did Parkhurst and Jordan's method, but which gave directly, when once calibrated by means of stars of known colors, the color of any star observed. The method depended simply upon a determination of the ratio of exposure times necessary to produce photographic and photovisual, or more briefly blue and yellow, images of the same size. For the sake of convenience, and also as a matter of precision, images used in this determination were all taken on the same plate. An isochromatic plate exposed behind a yellow filter registered the yellow image. The necessary blue images, or to use better terminology, possibly, the predominately blue images were taken by exposing the same plate without the filter.

In the simplest case there appeared for each star on the plate a short series of blue images formed by exposures of which the exposure times of the successive members increased regularly in a geometrical progression with a constant ratio of, say, two. There also appeared besides this series of blue images one yellow image. In order to determine the exposure ratio and hence the color of the star under consideration, the diameters of the blue images, or some measures of their diameters, were plotted against the logarithms of their exposure times, and from the resulting curve the exposure time required to produce a blue image of the same diameter as the yellow image was determined. The ratio of the exposure times necessary to produce blue and yellow images of the same size fixed at once an approximate color index for the star, provided that the plate-filter-telescope combination had previously been calibrated by applying the exposure-ratio method to stars of known color.

The adjective "approximate" is used advisedly in describing the first value of the color index obtained. There are, generally speaking, two sources of error affecting the first value of the color index obtained from the exposure ratio: 1. The effect of extinction. 2. The Purkinje effect.

The first of these arises from the fact that values of photographic and photovisual extinction at any given altitude differ. If the calibration plate and the field plate were taken at different altitudes, there will be a constant error in the colors derived from the field plate. This can be eliminated by applying the proper differential extinction correction which can readily be computed from a knowledge of the altitudes at

which the two plates were taken and the extinction coefficients of the observing station.

The second source of error is more troublesome and is due to the unfortunate fact that photographic plates are afflicted with a Purkinje effect just as the eye is. Thus if two stars of different apparent magnitudes have the same exposure ratio, it is not necessarily the case that they will have precisely the same color. Because of the Purkinje effect, the conversion factor for converting exposure ratio into color index varies with the size of image under consideration. There are two ways of eliminating this effect: a. The yellow exposures can be of such lengths that the images dealt with are always of the same size. b. A curve of Purkinje corrections to be added to the derived colors can be derived from the calibration plate as a function of image size.

The exposure-ratio method has been used successfully by Seares in examining the parallelism of the photographic and photovisual magnitude scales of the North Polar Sequence,[64] by Sternberck,[65] who made an investigation of the general procedure on the basis of the equations of photographic action of Kron; by Baade and Malmquist;[66] by Shajn[67] for the investigation of double stars; by Malmquist[68] for the determination of the colors of 3700 stars in the vicinity of the north galactic pole, and by others.

At the same time that Seares was developing his exposure-ratio method of determining color indices a completely different method of studying star colors was under investigation by Tikhoff.[69] Tikhoff's method utilized the chromatic aberration of the objective for separating light of different wave lengths in the manner of a "longitudinal spectrograph." In front of the objective was placed a circular diaphragm that screened the central portion of the objective and left free a ring-shaped zone. An extra-focal photograph taken with a camera equipped with such a circular diaphragm exhibited two principal parts for each star image: a ring, which was formed by the light for which the objective was achromatized (we will assume in this description that the objective has a color curve of the customary shape), and a central condensation, or more or less sharply defined point, corresponding to radiation which had its focus in the plane of the plate.[70] A very blue star showed a rather intense broad ring, which was composed of the predominantly blue light of the star, and a faint red dot in the middle of the ring. Actually, the dot would also be relatively bright if all blue

[64] *Trans. I. A. U.*, **1**, 79, 1922.
[65] *Veroff. der Univ. zu Berlin-Babelsberg*, **5**, 2, 1924.
[66] *Hamburg Mitt.*, **5**, No. 21, 1925.
[67] *Pulkova Bul.*, **10**, 276, 1925.
[68] *Medd. Lund Astron. Obs.* Ser. II, **5**, 21, 1925.
[69] *Bul. de l'Acad. Russe des Sciences*, **5**, No. 8, 1916; *A. N.*, **218**, 145, 1923.
[70] The general form of the color curve of a normal objective makes it apparent that this point will be composed of light of two widely separated wave lengths.

light were transmitted by the atmosphere and the photographic objective, but since the far blue and ultraviolet light does not, for one reason or another, arrive on the plate, the central dot in such a photograph is the result of exposure to the predominantly red light in which a blue star is deficient. A blue star therefore showed a strong ring and weak dot. A red star, on the other hand, showed a strong central dot (red light) and a faint circle (blue light). The ratio of the densities of the dot to the ring (or their difference) served as a measure of the star's color, which, through proper calibration, could be converted into the customary color index. In this method as in Seares', care was required to eliminate the Purkinje effect (in practice, the spots and rings were handled separately in the reduction), and the effect of differential extinction.

The Tikhoff method has been investigated by several observers. Tamm,[71] in 1922, independently proposed precisely the same method and tested it; Sternberck[72] modified the procedure slightly, devising a method which determined exposure ratios in the manner of Seares' method; Opik,[73] in 1924, examined the method and by it determined color-equivalents for 104 stars.

In 1929 Trumpler[74] devised still another method of determining color indices which involved the use of a half-color-filter made by cementing two differently colored gelatin films next to each other between thin glass plates. This half-color-filter, one half of which transmitted yellow light, the other half blue light, was used in the same general way as the platinum half-filter already described. Two exposures of approximately the same duration were made on the same plate; the filter was rotated through 180° between the exposures.

For making the reductions it was assumed that a sequence of photographic magnitudes had by other means already been established in the area under study. With these magnitudes a reduction curve was derived from the measurements of star images taken through the blue filter, and approximate magnitudes for those stars photographed through the yellow filter could be obtained by making use of this curve. These "quasi-visual magnitudes," as Trumpler called them, however, required correction for the difference between the blue reduction curve which was used, and the yellow reduction curve which should have been used, that is, for the Purkinje effect, and likewise required adjustment for zero point. The Purkinje correction was determined by means of pairs of exposures of long and short duration taken on the same plate. The zero point correction of the final color system was determined through observations of stars of known color or spectral class.

[71] *A. N.*, **216**, 331, 1922.
[72] *Op. Cit.*
[73] *Pub. de L' Obs. Astron. de l'Univ. de Tartu*, **26**, No. 3, 1924.
[74] *L. O. B.*, **14**, 89, 1929.

The half-color-filter method has been successfully applied by several of Trumpler's students, notably Kreiger,[75] Zug,[76] and C. E. Smith.[77] While somewhat more complicated in application than Seares' method, and requiring additional information in the form of a sequence of photographic magnitudes in the area under investigation, the half-color-filter method may have some slight advantages over the exposure-ratio method as indicated by certain theoretical studies.

Still other methods of determining colors have been suggested. In 1936 Rosenberg,[78] following a suggestion made earlier by Fuhrer,[79] placed two small-angle prisms (one made of red glass, the other of blue glass) base to base, and located them in the light beam of a reflecting telescope about 20 cm in front of the focal plane of the mirror, thus obtaining a double image of each star recorded on the plate.[80] These two images, formed by passing through differently colored filters, and therefore being differently colored, made different impressions on the plate. As in the exposure-ratio or half-color-filter methods, the difference in the photographic images observed yielded for the star under study a color equivalent. Rosenberg found that the prisms made from Schott OG2 and BG2 filters in conjunction with Wratten and Wainwright Panchromatic plates formed a satisfactory combination; the effective wave lengths of the color systems were 4015A and 6165A, and the images of a star of average color were of the same size, a desirable situation from the point of view of accuracy.

Establishment of an intensity scale for the plates was accomplished through a method of variation of exposure times, the relation thus derived being carefully checked by means of exposures on the Polar Sequence, and by means of exposures obtained with an objective grating. Seares' method of exposure ratios could be employed to good advantage with this apparatus, the necessary yellow and blue images being obtained simultaneously.

A variation of this method, suggested a few years ago, involves the use of larger prisms (either colored or in combination with filters) placed in front of the objective. This method would enable color indices to be derived for all the stars recorded on the plate.

Also in the year 1936, Öhman[81] proposed his method of determining

[75] *L. O. B.*, **14**, 95, 1929.
[76] *L. O. B.*, **16**, 119, 1933. Zug used a somewhat modified procedure.
[77] *L. O. B.*, **18**, 39, 1937.
[78] *Ap. J.*, **83**, 67, 1936.
[79] *Pub. Kiel Obs.*, **19**, 1933.
[80] The refracting angle of these filters was small, only 15′, hence the dispersion introduced was negligible. Even faint star images showed no sensible elongation.

It should be mentioned, of course, that only the star in the center of the field could be observed with this apparatus, as the cones of light of stars located in other parts of the field did not fall equally on the two prisms in front of the photographic plate.
[81] *Stockholm Obs. Medd.*, No. 28, 1936.

star colors by means of the principle of rotary dispersion, in the same general manner employed previously by Zöllner in changing the color of the artificial comparison star in his photometer by means of a quartz plate and a Nicol prism. Öhman employed in his device three plane crystal plates which he palced in front of the photographic plate. The light first passed through a thin (4 mm) calcite plate that split the light beam into two plane polarized components. These entered a quartz plate which was cut perpendicular to its axis and which rotated the plane of polarization to a different degree for each color. The ultraviolet light (λ 3700) was rotated 180°; the green light (λ 5120), 90°. Light that emerged from the quartz plate entered a second thin calcite plate turned 90° to the first. As a result of this arrangement four images of each star appeared in the form of two pairs, each pair having a different spectral composition or color. If ordinary photographic plates were used, there were, essentially, (as far as the effectiveness of the plates was involved) a pair of blue and a pair of ultraviolet images for each star photographed. These pairs, of course, had different intensities for stars of different colors, and thus gave photographic images of different sizes from which color indices could be derived.

Other methods suggested for determining star colors have involved the reflection of light from the front and back (silvered) surfaces of a yellow filter turned at an angle of 45° with the optical axis of the telescope and placed between the objective and its focal plane. The light reflected from the front surface retained approximately its originally spectral composition; the image (or images in the case of a bright star) arising from the light traversing the filter two or more times and reflected from the silvered back of the filter became colored. Thus two images of the same star composed of light from different portions of its spectrum could be photographed simultaneously on the same plate and could be made to yield a color equivalent for the star. Still another scheme has made use of a filter which reflected and transmitted selectively, one band (or group of bands) of color being reflected and forming one star image, the remaining regions of color being transmitted and forming a second image. Thus again, two colored images could be obtained from each star, and photographed simultaneously but on separate plates to give, subsequently, a color equivalent.

Effective Wave Lengths Determined Photographically

A color equivalent for a star may be established in another and independent manner through a determination of the effective wave length of the star's light. Determinations of this quantity were made visually, it will be recalled, by Comstock in 1896, in an investigation of differential refraction. Similar investigations, save for the fact that they were carried on photographically and with an objective grating rather than with two slits in front of the objective, were carried on in 1900 by the

Henry brothers[82] at Paris, and later, in 1907, by Hertzsprung,[83] who suggested that the general method might be used to determine color equivalents. Shortly thereafter, O. Bergstrand[84] followed Hertzsprung's suggestion and determined color equivalents in the form of effective wave lengths for 92 stars. A discussion of these observations showed that there existed a very clear relationship between the effective wave lengths and the visual color estimates of Müller and Kempf, or the spectral classes of Harvard.

Observations of effective wave lengths are, in principle, made quite simply. A relatively coarse objective grating is placed before the objective, the distance between the points of maximum photographic density in the two first order spectra on either side of the central image is measured, and from the supposedly known constants of the instrument this distance is converted into an effective wave length. The investigations of Bergstrand and others have shown that there are numerous sources of error in such measurements, however, and that the observational procedure is not so simple in practice as it is in principle. The measurements are influenced by the Purkinje effect, in some instances very greatly, and are critically dependent upon the properties (particularly the achromatism) of the optical system used. They are very sensitive to changes in focal length, changes which, in turn, influence the Purkinje correction. The measurements are also affected by atmospheric dispersion, by the distance from the center of the plate of the object being measured, and, depending upon the quality of the objective used, occasionally by the position angle of the wires of the grating. They are likewise dependent upon the quality of the sky during the exposure, results obtained through a clear atmosphere being found to differ systematically from those obtained through a slightly hazy atmosphere. The results obtained are further affected by certain purely photographic effects, such as photographic repulsion, and probably also by chemical fog.

With so many sources of error apparent from discussions of the observations, it became obvious that in order to realize the full usefulness of the effective-wave-length method it would be necessary to adopt some standards of reference with which all observers might standardize their results. In 1922 Bergstrand and Rosenberg[85] proposed that such a sequence of stars of standard effective wave lengths be established, and suggested a series of 25 stars north of declination +79°, ranging in brightness from magnitude 4.6 to 6.3, and in spectral type from B to M, and asked that effective wave lengths be determined for these stars by as many observers as possible. Unfortunately, the stars in the

[82] *Conf. Astrogr. internationale de juillet 1900, Circulaire* No. 8, 1901.
[83] *Bul. Astronomique*, **25**, 1, 1908.
[84] *Nova Acta Reg. Soc. Sci. Upsala*, Ser. IV, **2**, No. 4, 1909.
[85] *A.N.*, **215**, 447, 1922.

list are spread over a large area of the sky, and cannot be observed all at one time. Also they are rather bright to be observed conveniently with large instruments.

Various observers have modified at least to some degree the general procedure of determining effective wave lengths. Lindblad,[86] for example, introduced the minimum wave length, λ_{min}, which he defined as the shortest wave length in the spectrum of a star that had any effect on the photographic plate during a particular exposure. This was determined in a manner completely analogous to that employed in the determination of effective wave length. The distance between the inner limits of, say, the two first order spectra were measured and the wave length of these points found[87] by the same process used to form effective wave lengths from measurements of the separation of the photographically densest portion of the spectra.

Another modification was introduced by von Kluber,[88] who employed, in place of an objective grating, a small round prism of 1° angle which was placed over the center of the objective in the manner employed by the Harvard observers for establishing a magnitude scale. The short spectra formed by this prism were used in the same manner as those of the objective grating; the linear distance between the focal image formed in the normal manner by the light which did not pass through the prism and the point of maximum intensity in the spectrum formed by the light which traversed the prism was measured and reduced to effective wave length. Von Kluber's method gains its main advantage from the fact that it is not wasteful of light as is the objective grating method.

During the period of time which has elapsed since Bergstrand's first work, a large number of observers have made observations of effective wave lengths. The most notable contributions to the field are those of Hertzsprung,[89] Lindblad,[90] Bergstrand,[91] and the observers at the Greenwich Observatory.[92]

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[86] *Arkiv f. Matem., Astron., och Fysik*, **13**, No. 26, 1918; *Ap. J.*, **49**, 289, 1919.

[87] Lindblad used λ_{min} in conjunction with λ_{eff} in a determination of the absolute magnitudes of the stars.

[88] *Atr. Abt. Ergb. zu den A. N.*, **5**, No. 1, 1925.

[89] *Potsdam Publ.*, No. 63, 1911; *Copenhague Mem. de l'Acad. R. des Sci. et des Litt., Sec. des Sci.*, 8me Ser. IV, No. 4, 123 (a catalog of λ_{eff} for 1246 stars in the Pleiades); *Ap. J.*, **55**, 370, 1922 (a catalog of λ_{eff} for 129 stars within 0°.5 of the north pole).

[90] *Op. Cit.*

[91] *Op. Cit.; Jubilaumsnummer der A. N.*, **3**, 1921 (catalog of λ_{eff} for 803 stars in the Milky Way, $\alpha = 19^h\,54^m$, $\delta = +36°\,10'$).

[92] *Determinations of Effective Wave Lengths of Stars Made at the Royal Observatory, Greenwich, in the Years 1920 to 1925 under the Direction of Sir Frank W. Dyson*, London, 1926. (Catalog of λ_{eff} for 4472 stars observed by Davidson and Martin.)

Photographic Spectrophotometry

One of the important advances of the second photometric period was found in the concept and growth of spectrophotometry. During the third photometric period spectrophotometry has continued its growth, which became particularly rapid after the years 1915-1920, a period during which photographic photometry in general was gaining a new importance, and likewise during which the field of spectroscopy was expanding with very great rapidity.

The principal problems of spectrophotometry are: 1. The determination of the intensity distribution in the continuous background of the spectrum of the star or other luminous body under study; 2. The determination of the amount of energy removed from the continuous background by an absorption line (the equivalent width), or the amount of energy (relative or absolute) contained in emission lines; 3. The determination of the profiles of individual spectral lines.

The Calibration of the Plate. In all of these problems one of the primary considerations is the establishment of an intensity scale on each photograph (and preferably for each wave length to be studied) so that an observed value of photographic darkening can be reduced to the equivalent light intensity which produced it. The number of methods which have been devised for establishing such a scale is now quite large.

The first application of photography to the problems of stellar spectrophotometry appears to have been made (as were so many photometric "first applications") by E. C. Pickering[93] in 1891, when he compared the energy distribution in the spectra of a number of stars with that of the sun, which was assumed known from bolometric measurements made by Langley. Pickering made these measurements differentially as most similar measurements are made today, and in this way avoided or eliminated a great many sources of error and difficulty such as the absorption of light by the optical elements used in the spectrograph, unequal response of the photographic plate to different wave lengths, prismatic dispersion, and so forth. The method employed was simple and direct, but, unfortunately, not very accurate owing to the fact that an intensity scale was not established on each plate. There was, moreover, a lack of proper comparisons among the objects studied.

Some years later, in 1914, Rosenberg[94] compared the distribution of energy in the spectra of 91 stars with that of the sun. The comparisons of light intensity in the spectra of the various stars were made, wave length for wave length, with the spectral energy distribution of either α Aquilae or β Orionis, which served as intermediate standards. The spectral energy distributions of these intermediate standards were de-

[93] *A. N.*, **128**, 377, 1891. An objective prism was used to obtain the spectra.
[94] *Abh. d. Kais. Leop. Carol. Deutsch Akad. d. Naturforscher Nova Acata*, **101**, No. 2, 1914.

termined, again wave length for wave length, through comparison with the sun, of which the spectral energy distribution was assumed known from bolometric measurements.

In order to have a scale with which to convert photographic density into equivalent light intensity in any of the spectra he was studying, Rosenberg made on each plate a series of exposures of the spectrum of Polaris. The exposure times of successive members of this series varied in geometric ratio. The intensity ratio corresponding to this exposure ratio was determined through the use of a neutral absorbing screen of known absorption constant.

In the same year that Rosenberg described his observations, Brill[95] published a spectrophotometric study of Nova Geminorum No. 2 in which he established a photometric scale by means of a tube photometer of the general type employed by Parkhurst and Jordan in their extra-focal stellar photometry. This general method of establishing a reduction curve, a method commonly used today, becomes inaccurate, unfortunately, if observations are to be made over a considerable wave-length range inasmuch as the form of the reduction curve is a function of wave length.[96]

In 1918 Hertzsprung[97] described his prism-crossed-by-grating method of spectrophotometry in which an objective grating was used in conjunction with an objective prism, the direction of dispersion of grating and prism being at right angles to each other. Plates taken with this apparatus showed, in addition to the main spectrum formed by the objective prism, weaker flanking spectra (diffraction images of the main spectrum) which were formed by the grating. These weaker spectra differed in brightness from the central spectrum and from each other by known amounts which could be calculated from the grating constants, and thus an intensity scale was established on each plate with only one exposure.

Still another method of establishing a spectrophotometric scale was tried in 1923 by Plaskett[98] in a series of experiments with the photographic wedge method originally proposed as a laboratory procedure by Merton and Nicholson.[99] In front of the spectrograph slit was placed a neutral absorbing wedge, with its density gradient parallel to the direction of the slit. The light from the source for which the spectral intensity distribution was to be determined was arranged to cover this wedge uniformly.

One boundary of the spectrum photographed through such an apparatus was straight as it customarily is, but the other boundary of the

[95] *Publ. Potsdam Astroph. Obs.*, No. 70, 1914.

[96] The inaccuracies thus introduced can be largely eliminated, however, if the physical constants of the emulsion are known.

[97] *A. N.*, **207**, 75, 1918.

[98] *Pub. Dom. Astroph. Obs. Victoria*, **2**, No. 12, 1923.

[99] *Phil. Trans. Roy. Soc., A*, **217**, 237, 1917.

spectrum was irregular, and the spectrum as a whole resembled the profile of a range of hills. The higher the hill, that is, the wider the spectrum, the greater the effective intensity of the source at that particular wave length. On each plate of a stellar spectrum taken with such a wedge in front of the slit, the spectrum of a standard source of known energy distribution was photographed through the same apparatus and as nearly as possible under the same conditions as those under which the stellar spectrum was photographed. On such a standardized plate, the relative widths of the stellar and standard spectra at a particular wave length combined with the known properties of the wedge as determined from laboratory studies served to establish the ratio of the intensity of the stellar radiation to that of the standard source at that wave length.

Using the positive crater of a carbon arc as a comparison source, Plaskett determined by this wedge method the intensity distribution in the solar spectrum and in the spectra of six stars.

Sampson,[100] starting in 1922, measured the intensity distribution in the spectra of a number of the brighter stars relative to the intensity distribution in the spectrum of Polaris. His scale was established through laboratory calibration of the plates, a procedure which involved determining the values of certain parameters in a theoretical expression giving the relationship between intensity, exposure time, and plate darkening.

In 1924 Baillaud[101] reported his spectrophotometric researches on nine stars, and described his "echelle de teintes" method by means of which he compared the energy distribution in the spectra of the stars with that of a standard incandescent lamp which was, in turn, compared with the positive crater of a carbon arc that served as a source of known energy distribution. In Baillaud's method the spectra of the star and of the standard lamp were photographed simultaneously on the same plate with exposures of the same duration. The slit through which the light of the standard source entered was made up of five steps or sections of different widths, so that five adjacent spectra of different and supposedly known intensities were formed. From these five steps a reduction curve for converting photographic blackening into relative light intensity could be formed for any wave length, and the intensity of the spectrum of the star could thus really be compared with the standard.

Other investigators have made use of a neutral step wedge in front of a slit of uniform width in a generally similar procedure.

Since these more or less experimental explorations have been made, the number of spectrophotometric methods and investigations has increased greatly. The number of methods of establishing reduction

[100] *M. N.*, **83**, 174, 1923; **85**, 212, 1925; **90**, 636, 1930.
[101] *Bul. Astronomique*, **4**, Fasc. 3, 275, 1924.

curves has grown at a particularly rapid rate inasmuch as the physicist and the chemist in the laboratory as well as the astronomer in the observatory have a deep interest in this branch of photometry. More spectrophotometric methods have been used or devised in the laboratory, in fact, than in the observatory. In Table V, which has been taken from a paper by G. R. Harrison[102] are listed the various ways of calibrating plates which have so far been used and are available in the literature on the subject.

TABLE V *Methods of imposing intensity calibration marks on photometric plates.*

			Selective Neutral	Requirements for use	Remarks
Single Exposure Methods	Auto-calibration		Step-sector disk Logarithmic sector	At slit, rapid rotation, stigmatic spectrograph.	Convenient and accurate if made and used accurately.
			Step-weakener Wedge-weakener	At slit, calibrate. stigmatic spectrograph.	Convenient and accurate once calibrated at proper wave-lengths.
			Step-diaphragm Wedge-diaphragm	Astigmatic optical system, careful adjustment.	Convenient but unsuitable for accurate work if neutrality is assumed.
			Step-diaphragm Wedge-diaphragm	Rowland type grating mounting.	Convenient for large gratings, but covers only short range at a setting.
			Step-weakener Wedge-weakener	At plate, astigmatic spectrograph or long even lines.	Very accurate and simple, once suitable weakeners obtained and calibrated.
			Theoretical astigmatism	Paschen or other fixed grating mount.	Not yet thoroughly tested.
			Theoretical line shapes	Large instrumental broadening.	Seldom used except for interpreting old spectrograms without intensity marks.
			Coarse crossed grating	Calibrate grating orders for intensity.	Useful in astronomical work or qualitative estimates.
			Geometrical shadow	Special cases only.	Seldom used.
	Auxiliary Source		Step-slit Wedge-slit	Continuous spectrum, stigmatic spectrograph.	Easy but questionable unless Eberhard effect avoided.
			Theoretical line ratios	Avoid self-reversal and excitation errors.	Useful when all else fails.
Multiple Exposure Methods	Steady Auxiliary Source		Variable diaphragms	Uniform beam section.	Careful tests for uniformity needed, usually less convenient than others.
			Wire gauze screens	Wide optical beam.	Avoid diffraction errors.
			Semi-neutral filters	Calibrate filters for transmission vs. wave-length.	Avoid refraction errors.
			Inverse square law	Long optical path.	Suitable scatterer needed, avoid atmospheric absorption.
			Variable slit length	Astigmatic spectrograph.	Simple if illumination carefully controlled.
			Variable slit width	Continuous spectrum.	Avoid diffraction errors and Eberhard effect.
			Diffuse reflection	Calibrate reflector.	Seldom used.
			Variable exposure time	Compensate reciprocity failure.	Often easiest method for qualitative work; to be used with discrimination.
			Variable sector disk	At slit, rapid rotation.	Avoid errors from extreme conditions.
			Control of source	Suitable calibrated source.	Seldom convenient.
			Polarisers	Transparent polarizers.	Seldom convenient for photography.

The determination of line intensities and profiles. At approximately

[102] *J. O. S. A.*, **24**, 59, 1934. For a comprehensive survey of the methods of spectrophotometry the reader is referred to this paper by Harrison and an earlier one by the same author contained in *J. O. S. A. and R. S. I.*, **19**, 267, 1929. Similar surveys which will be found useful for detailed photometric information are: L. S. Ornstein; *Proc. Phy. Soc. London*, **37**, 334, 1925; *Phy. Z.*, **28**, 688, 1927; H. B. Dorgelo, *Phy. Z.*, **26**, 756, 1925; "Photographic Photometry" by G. M. B. Dobson, I. O. Griffith, and D. N. Harrison, Oxford University Press, 1926; L. S. Ornstein, W. H. J. Moll, and H. C. Burger, "Objective Spectralphotometrie," Vieweg, 1932.

the same time that interest in the intensity distributions in the continuous backgrounds of spectra began to grow, so too did interest begin to increase in individual lines seen against those backgrounds. This interest has taken two courses; interest in the total absorptions of individual lines (or in the relative or absolute energy contained in the line in the case of emission lines), and interest in the profiles of the lines. The amount of astrophysical knowledge to be gained from studies of such data is very great. The determination of such data, however, especially line profiles, is often difficult. The profiles we observe on a spectrum are not the true profiles or intensity distributions within the lines, but the true profiles distorted by various instrumental effects which we must eliminate in the course of the reductions. Finite slit width, diffraction by finite aperture, scattering by dust and impurities in the transparent media, imperfect focus, irregularities in the optical surfaces or gratings, photographic spread, all tend to distort the true profile of the absorption line, most of them to broaden it.[103] Very many procedures of correcting for these distortion factors have been devised; the literature on the subject is quite extensive.

Among the developments of particular interest in this field might be mentioned those of Redman and of Shane. Redman[104] had made use of a monochromator in front of the slit of his spectrograph and thus allowed only a very narrow wave-length region in the immediate vicinity of the line under study to enter the instrument. This procedure eliminated the greater part of the scattered light tending to distort the line profile. The remaining instrumental profile was determined from a study of very narrow emission lines, and the observed profiles were corrected for influence of instrumental profile through the solution of an integral equation in which the instrumental profile appeared as the kernel.

Shane[105] has devised a method of determining line profiles which employs a Fabry and Perot etalon interferometer in front of the slit of a plane grating spectrograph. The use of such a device diminishes the danger of systematic errors in the determination of the observed profiles since these can be determined from observations of fringe maxima, and also reduces the uncertainties in going from observed to true profiles, since the instrumental profile with an interferometer is very narrow, and the observed and true profiles differ by small quantities only.

[103] Certain other purely photographic effects may be mentioned as also affecting the line profiles. Among these are Eberhard effect, reciprocity failure and the difficulties which can arise from differences in exposure times between standards and spectrum, the effect of trailing in the case of a star (intermittency effect), grain effect in the emulsion, and so forth. These are, of course, of importance in the determination of line intensities as well as profiles, and, in a number of instances, in the study of the intensity of the continuous spectrum also.

[104] *M. N.*, **95**, 290, 1935; **95**, 742, 1935; **97**, 552, 1937.

[105] *L. O. B.*, **16**, 76, 1932; **19**, 119, 1941.

Equivalent widths of absorption lines in spectra are constant data not affected by instrumental profile, stellar rotation, or stellar pulsation. They may be much more readily determined than profiles, and require for their determination only measurements of microphotometer tracings properly reduced by means of a characteristic curve determined from photometric standards impressed on the plate in one of the various ways already discussed.

Emission lines can be dealt with in several ways: profiles can be determined as for absorption lines, or, when emissions accompany a continuous spectrum, their intensities can be expressed in the same way as for absorption lines, by using the continuous spectrum as unit intensity and expressing intensities as equivalent widths.

Among the several recent outstanding catalogs, dealing with the photomery of spectral lines, two merit special mention. The first of these is the *Utrecht Photometric Atlas of the Solar Spectrum* by M. Minnaert, G. F. W. Mulders, and J. Houtgast, which gives intensity curves covering the complete solar spectrum from λ 3612 to λ 8771 based on photographs taken at the Mount Wilson Observatory, together with an appendix covering the region λ 3332 to λ 3627 as derived from plates taken at Utrecht. The scale in wave length is about 20 mm per angstrom; the ordinates of the curve are directly proportional to the intensity of the solar spectrum, a feature which gives the *Atlas* great value.

A similar atlas of representative stellar spectra is being prepared by Hiltner at the Yerkes and McDonald Observatories. This atlas, made possible by the direct intensity recording microphotometer in the development of which Hiltner has taken an important part, will, when completed, be of great value to all astrophysicists.[106]

The development of microphotometers. The rapid advance which has taken place in the field of spectrophotometry during the last two or three decades can probably be traced to the improvement of the various automatic instruments for measuring photographic density more than to any other single cause. These measuring instruments, known as microphotometers or microdensitometers, contain as fundamental features a source of light to provide a measuring beam traversing the plate to be measured, a means of limiting that beam to a desired area of the emulsion, and a means of comparing the brightness of that beam with the brightness of another (or a part of the same) beam which has passed through a clear portion of the plate. Originally these measurements or density-matches were made by eye; today they are more commonly made by means of a sensitive physical element, such as a thermocouple or photocell, which, when connected to a deflecting instrument,

[106] For a further review of the rather specialized subjects of line intensities and profiles the reader is referred to "Handbuch der Experimentalphysik," **26**, 467 ff., edited by B. Stromgren, Leipzig, 1937.

such as a galvanometer or electrometer, will give an objective indication of the amount of radiation falling on it. Such measuring instruments are of two main types, deflecting and null, according to whether the intensity of the radiation passing through the plate is measured directly, or whether the density of the plate is balanced against a variable and known density, the sensitive instrument being used merely to indicate balance as the eye does in an eye-match instrument.

The original deflection microphotometer was designed by Koch[107] in 1912 at approximately the same time that Stetson was producing his first successful photometer for measuring photographic star images. In Koch's instrument light from a lamp (originally a Nernst lamp) passed through an optical system which focused it on the plate, through which it passed, to be imaged again on a photoelectric cell which was connected to a string electrometer. A second projection system was used to throw an image of the electrometer thread on a recording plate, which was moved by clockwork in exact relation to the motion of the plate being measured. Koch's original instrument, the prototype of photoelectric deflection microphotometers, has been subjected to various modifications and improvements throughout the years.

In 1921 Moll[108] devised a recording microphotometer of properties generally similar to Koch's instrument except for the fact that a thermopile was used in place of the photoelectric cell. This instrument, too, has been subjected to many modifications and changes.

The thermoelectric type of microphotometer is generally simpler in construction than the photoelectric type, but the latter is generally more sensitive, has a quicker response, a greater freedom from thermal disturbances and is more limited in spectral sensitivity than a thermoelement, so that less complete achromatization of focusing lenses is required. In addition, photoelectric cells can readily be used to operate amplifiers and other instruments which require fairly great voltage variations.

In making an automatic record of the deflections of a microphotometer one usually obtains a plot of the galvanometer or electrometer deflection against distance along the plate. These deflections, measurements of photographic density, must be interpreted in terms of the intensity of radiation which produced that density. This interpretation is made by means of the calibration curve for the particular plate and wave length under consideration. Unfortunately the process involved is often lengthy and tedious, and several devices to make these reductions less time-consuming have been tried. They have been of two general types: instruments affording a mechanical reduction of ordinary microphotometer tracings to intensity curves, and instruments designed to obtain an intensity record directly from the photographic plate. Gen-

[107] *Ann. Phys.*, **39**, 705, 1912; **41**, 115, 1913.
[108] *Proc. Phys. Soc. London*, **33**, 207, 1921.

erally speaking, however, all methods for performing these reductions by mechanical means have suffered from the necessity of drawing or forming a mean reduction curve which was used in wave-length ranges in which it was not strictly applicable.

A device, developed at the University of Michigan by Williams and Hiltner,[109] has overcome this objection. This new self-recording direct-intensity microphotometer "requires two plates, or two halves of one plate, mounted on separate carriages, which are caused to move simultaneously in the direction of dispersion with the motion so geared that the plates are kept together in wave length. One plate contains a calibration spectrum across which the intensity is known to vary exponentially with distance; the other plate contains the stellar spectrum under examination. A beam of light in the standard form of a projected slit image scans each plate at the same wave length. By proper optical, electrical, and mechanical means the calibration spectrum is caused to move at right angles to the direction of dispersion in such direction and amount that the density of the photographic image in the calibration spectrum is always equal to the density in the stellar spectrum. The analysing beam thus traces out on the calibration spectrum a curve whose photographic density at any wave length equals that of the stellar spectrum at the same wave length. The motion of the calibration spectrum across the direction of dispersion is transferred, by means of a cam and mirror, to the motion of a spot of light across a drum containing recording paper. The cam is so shaped that the distance moved by the spot of light across the recording drum will be proportional to the relative intensity of the light which originally impressed itself upon the calibration spectrum. Since the calibration spectrum and the stellar spectrum are kept together in both wave length and density, the motion of the spot of light on the drum will be proportional to the relative intensity of light which impressed itself upon the stellar spectrum, and direct intensity tracings will result.[110]"

[109] *Pub. A. A. S.*, **10**, 33, 1939; *Pub. Obs. Univ. of Mich.*, **8**, 45, 1940; *Ap. J.*, **98**, 43, 1943.

[110] Williams and Hiltner, *Pub. Obs. Univ. of Mich.*, **8**, 45, 1940. For a review of microphotometers in general (not of the Williams-Hiltner type) the reader is referred to H. Kienle's article in the "Handbuch der Experimentalphysik," Leipzig, 1937, **26**, 707 ff.; H. B. Dorgelo, *Phys. Zeitschr.*, **26**, 774, 1925; G. R. Harrison, *J. O. S. A.* and *R. S. I.*, **10**, 157, 1925; **19**, 296, 1929; *J. O. S. A.*, **24**, 59, 1934; G. M. B. Dobson, I. O. Griffith, and D. N. Harrison, "Photographic Photometry," Oxford Univ. Press, p. 55, 1926; L. S. Ornstein, W. H. J. Moll, and H. C. Burger, "Objective Spectralphotometrie," Vieweg, p. 56, 1932.

(To be continued)

Kepler's Defense of Tycho against Ursus

By EDWARD ROSEN

In 1595 Kepler unwittingly became involved in the fierce dispute between Tycho Brahe, the foremost astronomer of the later sixteenth century, and Nicholas Reimers, who called himself Ursus (the bear).[1] Still an unknown youth, Kepler had not yet met either adversary in person, but he had read Reimers' principal work, the *Fundamentum astronomicum* (Strassburg, 1588), having been able to borrow it for three days.[2] In the hope of arousing interest in his own supposed discovery of a connection between the planetary distances and the regular solids, he addressed an unsolicited letter[3] to Reimers, who at that time held the post of Imperial Mathematician to Rudolph II, Holy Roman Emperor. In his letter Kepler bestowed extravagant praise on Reimers, saluting him as far and away the leading mathematician of the age. With insincere flattery he declared that whatever he knew about mathematics he had acquired from Reimers, that is to say, from his writings. Kepler was subsequently told by his actual mathematics teacher: "I cannot believe that you wrote such a letter."[4] He long regretted his ill-considered utterances and frequently sought to make amends; for example, in 1600 he said: "Those who know me well will be surprised that I honored Ursus as my teacher instead of Maestlin."[5]

The Imperial Mathematician, however, took no notice of his correspondent, so long as the latter was obscure. But after learning of the stir created by the *Cosmographic Mystery* in 1596, he sent Kepler a belated reply in May, 1597.[6] In that same year he issued at Prague his *De astronomicis hypothesibus,* with its venomous attack on Brahe; and he incorporated Kepler's letter in it, without Kepler's knowledge or consent, thereby unscrupulously making it appear that in his duel with Tycho he was supported by the author of the *Cosmographic Mystery.* Reimers took good care not to send Kepler a copy of the book.[7]

But when a copy reached Brahe in March, 1598, he noticed Kepler's letter. Thereupon he wrote Kepler a statement of his accusations against Reimers, and requested a prompt expression of opinion.[8] Kepler answered that his eulogistic letter to Reimers was couched in a poetic style, and he excused its exuberant diction on the grounds of immaturity and haste.[9] He finally managed to get hold of Reimers' book on May 25, 1599, when he received a copy from his friend and patron, J. G. Herwart von Hohenburg, Chancellor of Bavaria.[10] Complying with Herwart's request for his reaction to the book, he included a critique in his reply of May 30.[11] To his teacher, Maestlin, he characterized Ursus as a madman and more of a jackass than a bear.[12]

Meanwhile the Catholic Counter-Reformation was moving ominously toward him, threatening his livelihood. Hoping to secure an appoint-

ment to Tycho's staff, inquiries in other directions having proved fruitless, in January, 1600, he undertook an exploratory trip to Prague. There he first encountered Reimers, whom he upbraided; but to avoid recriminations, he concealed his identity until the very end of the interview.[13] Within the next week or two, he went out to Brahe's place at Benatky (Benatek), near Prague, and thus began the association which so profoundly affected the development of modern astronomy.

While at Benatky Kepler mentioned the critique of Reimers' book which he had prepared in response to Herwart's request of the previous May.[14] But he had evidently not brought a copy of the critique with him to Benatky. For when he attempted in March, at the instance of Tengnagel, a member of Tycho's entourage, to reproduce the section that most vitally concerned Brahe, he declared at the outset: "I replied approximately as follows, so far as I recall."[15] In April a quarrel broke out between Kepler and Brahe, and the latter fleetingly suspected that Kepler might surreptitiously join forces with Reimers against himself.[16] But Kepler's letter entreating his forgiveness allayed any such doubt.[17] About a month after their reconciliation Kepler returned to his home at Graz,[18] in the Austrian province of Styria, from whence he wrote to Tycho that he intended to expose Reimers' mathematical errors.[19]

In mid-August the farm hand from Ditmarschen, an illiterate until eighteen, who had taught himself the languages needed to master the science of the day, and by his own effort and native talent had risen from swineherd and plowman to university professor and imperial mathematician, only to be utterly ruined by his bitter feud with Brahe, died in disgrace.[20] But Tycho was relentless. Pressing a legal action against the dead man's book, he planned to publish the proceedings in a special volume; its second half was to be devoted to a discussion of the astronomical questions under dispute, and would include a contribution by Kepler. For this purpose the memorandum to Tengnagel was useless, since, as we saw just above, it carried a disclaimer of fidelity. Hence on August 28, 1600, Brahe requested of Herwart a short-term loan or certified transcript of Kepler's critique.[21] On the same day he wrote also to Kepler in Graz, encouraging the proposed refutation, and recommending a more extensive treatment with greater emphasis on his own originality;[22] the Emperor had already delegated to the Archbishop of Prague, he reported with grim satisfaction, the task of seizing and burning all the copies of Reimers' book that could be found.[23]

Compelled by religious persecution to leave Catholic Graz, and this time accompanied by his family, Kepler rejoined Brahe at Prague in October, 1600.[24] At Tycho's insistence, Kepler fulfilled his promise[25] of lifting from the other's aging shoulders the burden of composing a rebuttal of Reimers, which he entitled *A Defense of Tycho against Ursus* (*Apologia Tychonis contra Ursum*).

But the projected anti-Reimers volume, for which it was intended, remained unfinished business at the time of Brahe's death (October 24, 1601).[26] Kepler's thoughts now turned to independent publication. However, he was dissatisfied with the *Defense* as it stood, because he felt that it required additional research before going to press. Moreover, having been appointed Imperial Mathematician as successor to Tycho, he deemed it inopportune at that juncture to assail the memory of Reimers, Brahe's predecessor in that office. Hence he deferred publication, trusting that inflamed emotions would cool off with the passing of the years.[27] But his attention too was drawn to more urgent matters, with the result that the *Defense of Tycho* was not printed during his lifetime. It was found among his unpublished manuscripts by Christian Frisch, who edited Kepler's collected works, and to Frisch it owes its first and only appearance in print in 1858.[28]

He erroneously believed, however, that the composition of the *Defense* was begun at Graz early in 1601.[29] But the two halves of his pronouncement clash with each other. For during the first quarter of 1601 Kepler was not at Graz, since he came to Prague in October, 1600, as we have already seen, and remained in the imperial capital until April, 1601.[30]

Now let us test the soundness of Frisch's choice of the year 1601. The Preface to the *Defense* opens as follows: "Three years ago Nicholas Ursus, who during his lifetime was His Imperial Majesty's Mathematician, published the little book *De astronomicis hypothesibus.*"[31] Because this work appeared in 1597, we must infer that the *Defense* was started in 1600, not 1601. And Kepler suffered no lapse of memory with regard to the date of Reimers' book, for he adds that his own *Cosmographic Mystery* was published during the preceding year, and that he sent his overlaudatory letter to Reimers two years before, when he was twenty-three years old. The reader will recall that the *Cosmographic Mystery* appeared in 1596, and that the flattering letter to Reimers was written in 1595. Since it is dated November 15, 1595, and since Kepler tells us that he was born on December 27, 1571,[32] his twenty-third year still had over a month more to run. All these indications point inescapably, then, to 1600 as the year in which the *Defense* was begun.

But they do not authorize us to put the composition of the *Defense* in 1600.[33] For on February 8, 1601, Kepler reports: "On account of my illness, I am engaged in nothing but writing a refutation of Ursus, in which I deal exclusively with matters of science."[34] And in 1605 he recalls: "I was gripped by a fever from October, 1600, to August, 1601. During that time I wrote against Ursus at Tycho's bidding, and I assisted in his other enterprises according to his judgment and my own strength. . . From April to the end of August I went on a trip to Styria, while my wife remained behind at Prague."[35] Since this was a

business trip, which found Kepler staying with friends and having to travel about a bit too, it is altogether improbable that he wrote any part of the *Defense* while in Styria.[36] Again, the only activity which he records as having occupied him upon his return to Prague in September is a joint investigation of the solar eccentricity with Brahe, which continued until the latter's fatal illness set in.[37] Now it was Frisch's judgment that Kepler left the *Defense* almost, but not quite, finished.[38] If so, it would seem rather likely that Kepler did no further work on it after his departure for Graz in April, 1601.[39]

The threads have now been arranged on the loom. If they have all been tied in their proper place, and none has been overlooked that belongs to the pattern, then it would appear that the *Defense* was written at Prague in the half-year between mid-October, 1600, and April, 1601.[40]

Since its recovery almost a century ago, this brief essay by Kepler has, for some obscure reason, failed to attract the attention which its contents deserve. Two aspects of it in particular will repay close examination; one is Kepler's discussion of scientific method and the nature of an astronomical hypothesis, while the other concerns several important questions in the history of astronomy. If the present article succeeds in arousing an increased interest in the *Defense,* its publication will have been more than justified.

Notes and References

Abbreviations of works frequently cited:

A Anschütz, Karl *Ungedruckte wissenschaftliche Correspondenz zwischen Johann Kepler und Herwart von Hohenburg, 1599* (Prague, 1886); an offprint of "Drei noch unbekannte Briefe des Astronomen Joh. Kepler an Herwart von Hohenburg, 1599" (*Sitzungsberichte der k. böhmischen Gesellschaft der Wissenschaften,* math.-nat. Classe, 1885, 417-523).

F *Joannis Kepleri astronomi opera omnia,* ed. Christian Frisch (Frankfurt on the Main and Erlangen, 1858-71), 8 vols.

T *Tychonis Brahe dani opera omnia,* ed. J. L. E. Dreyer (Copenhagen, 1913-29), 15 vols.

[1] In his *Geodaesia Ranzoviana* (Leipzig, 1583), which was written in German, his name is spelled Reymers on the title page and at the end of the Preface (fol. A4r), and Reimers at the foot of the Conclusion (fol. L3v). For his subsequent works in Latin he assumed, in addition to Ursus, the surname Dithmarsus, to show that he came from the Ditmarschen district of western Holstein. Thus he appeared in print fully accoutered as Nicolaus Raymarus Ursus Dithmarsus. It is a mistake to identify him with any of the writers named Ursinus, as Ernst Zinner did in *Die Geschichte der Sternkunde* (Berlin, 1931), p. 469; or to split him in two, and make of his ghostly double a pupil of Brahe's, as J. H. von Mädler did in his *Geschichte der Himmelskunde* (Braunschweig, 1873), I, 194-95, 208. The conventional accounts of his controversy with Brahe, being drawn mainly from Tychonic sources, are heavily biased in favor of the Danish aristocrat against the peasant from Holstein; for an attempt to redress the balance see Rudolf Wolf, *Vierteljahrsschrift der naturforschenden Gesellschaft in Zürich,* **31**, 313-27, 1886.

[2] [*Ursum*] *nisi in Fundamento suo astronomico loquentem numquam audiveram, numquam videram* (FI, 236); *quo tempore epistolam illam scripsi . . . librum eius . . . triduo concesso raptim percurrerem* (FI, 221); *librum praeterea nullum videram ab ipso editum* (A, p. 37, 953-54). When Kepler wanted to consult it again in 1599, it was not available to him, because its owner was away from

home (A, p. 41.1111-14).

[3] Latin text in FI, 218-19; German translation in Max Caspar and Walther von Dyck, *Johannes Kepler in seinen Briefen* (Munich and Berlin, 1930), I, 24-25. In *Kepler and the Jesuits* (Milwaukee, 1944), p. 12, M. W. Burke-Gaffney's remark that "Kepler had heard of Reymers' book, but not of Brahe's, and in writing to Brahe he sang Reymers' praises" contains three historical errors:

(a) Kepler had read Reimers' *Fundamentum astronomicum,* not merely heard of it: *cum illam epistolam ad Ursum scriberem . . . paulo ante libellum eius, cui Fundamentum astronomicum nomen dedit, legissem* (A, p. 37.941-44); *cf.* J. L. E. Dreyer, *Tycho Brahe* (Edinburgh, 1890), p. 291.

Nicolao Raimaro Vrſo Diethmarſo, Mathematico Cæſareo nobiliſsimo.

Fragam.

QVI ignoti ad ignotos in longinquas regiones tranſmittunt epiſtolas; mirabiles ſunt homines. Te mihi notum pridem fecit illuſtriſsima tua gloria, quâ mathematicos huius ævi tantum præcedis unus, quantum Phœbæus orbis minuta ſidera. Sed nec tempus plura fert, nec Mathematicorũ eſt garrulitas. Hoc unum habe, tanti te à me fieri, quanti omnes docti te faciunt, quorum judicium aſpernari arrogantis eſt, collaudare modeſti juvenis. Cum itaq; præceptore te, id eſt libris tuis, hoc quantulũ eſt, cognitionis acquiſiveris in Mathematis; æquum duxi, ut te in re arduâ, nec ut mihi videtur, contemnendâ, conſulam. Si aprobaveris quod ajo, beatum me predicabo, proximum fœlicitatis gradum in eo ſtatuo, ut à te corrigar. Tanti eſt mihi tuum judicium. Hypotheſes tuas amo: ſed Copernicum ſatis admirari non poſſum, cujus Hypotheſes hoc habent, quod his Verſibus complexus ſum.

Quid Mundus, quæ cauſa Deo ratioq; creandi,
Vnde Deo numeri, quæ tantæ regula molí,
Quid faciat Sex circuitus, quo quælibet orbe
Intervalla cadant, cur tanto Iupiter & Mars
Orbibus haud primis interſtinguantur hiatu:
Accipe Pythagoræ monſtratum quinq; figuris.

Nam inter Saturnum & Iovem eſt Cubus, ſicut ima Saturni periodus, ſit Orbis circumſcriptus, ſumma Iovis inſcriptus, inter Iovem & Martem.

D

FIGURE 1

KEPLER'S LETTER TO REIMERS.

From Reimers' *De astronomicis hypothesibus* (Prague, 1597)

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Martem Tetraedron, inter Martem & Terram dodecaedron, inter Terram & Venerem Icosaedron, inter Venerem & Mercurium Octaedron. Ordinem hunc corporum neq; Mataphysici, neq; Mathematici cum ratione immutaverint. Iam & medij motus se accomodant, Est enim eorum dupla ratio ad distantias, scilicet quia (Vel eadem esset incitatio partium, in omnibus) propter majorem amplitudinem, quidem tardius redirent. Et jam accedit debilitatio in exterioribus, qualis accidit in lucidi radij extenuatione. Parùm uti inq; à Copernico disceditur, plùs tamen, si ex motibus medijs constituantur distantiae, quàm si ex corporibus. Nam ex correctione distantiarum per corpora sequitur differentia Prosthaphæreseων Apogæorum non major, quam in Saturno 12. m. in Ioue 25. m. in Marte 1. gr. 45. m. in Venere 1. gr in Mercurio 4'. m. Plura non scribo, judicium tuum expectans, quod non graveberis in gratiam nobilissimi juvenis D. Sigismundi VVagani, cuius instinctu scribo, hac vel proximâ occasione ad nos transmittere. Vale Sideribus & nostræ Scientiæ, decus Germaniæ. Gratij 15. Nouemb. Anno 1595.

Ex: Tua

discipulus,

M Ioannes Keplerus, Illustrium Styriæ provincialium Mathematicus.

FIGURE 2

KEPLER'S LETTER TO REIMERS (CONT.)

(b) Kepler had heard of Brahe's *De mundi aetherei recentioribus phaenomenis* (Uraniborg, 1588); see *Cosmographic Mystery*, ch. 1, 22 (FI, 113, 182).

(c) Kepler's letter in praise of Reimers was addressed to Reimers, not to Brahe. Kepler's letter to Brahe (December, 1597) said nothing about Reimers, and sang Brahe's praises (FI, 42-43).

[4] Letter from Michael Maestlin to Kepler, July 14, 1598 (FI, 232).

[5] FI, 236. Evidently unacquainted with the facts of the case, Grant McColley asserts: "It was with good reason that in his letter of 15 November 1595, Kepler addressed himself to Reymers as *'Tuae discipulus'*" (*Pop. Astr.*, **46**, 27, 1938). Incidentally, these two quoted words form an incomplete and ungrammatical combination only because McColley tore them out of the routine formula which closes the letter, as the accompanying illustration shows. Can he have failed to recognize the familiar abbreviation *Ex:*, which precedes them? Kepler was of course addressing a personage of the imperial court and hence, with appropriate deference, used the subscription *Ex* [*cellentiae*] *Tuae discipulus* (Your Excellency's pupil).

[6] FI, 219. The change in Reimers' attitude affords us an insight into the man's character. But this whole point was missed by Adolf Müller, who anachronistically supposed that the letter sent by Kepler to Reimers in 1595 accompanied a complimentary copy of the *Cosmographic Mystery*, which was not published until 1596; see Müller's *Johann Keppler, der Gesetzgeber der neueren*

Astronomie (Freiburg im Breisgau, 1903), p. 37, offprinted from *Stimmen aus Maria-Laach*, 1903, Ergänzungsheft 83. Actually, Reimers' letter of May, 1597, requested a copy of the *Cosmographic Mystery*, and Kepler promptly complied (FI, 36). Half a century before Müller confused these transactions, Frisch had explicitly remarked of Kepler's 1595 letter to Reimers: *ante editum Prodromum scripsit* (FI, 218).

[7] *Has* [*litteras*] *ille publicavit, nec me consuluit, nec facturum, nec factum nuntiavit, nec exemplar misit* (FI, 221); *Primum non dissimulavi me irasci Urso, qui epistola mea inconsulto me publicata foede abusus est* (FI, 282).

[8] TVIII, 46.37-48.7.

[9] FI, 220-23; Caspar and Dyck, *Briefe*, I, 93-98.

[10] A, p. 34.827-29; FI, 234.

[11] A, p. 36.931-p. 44.1231.

[12] FI, 235.

[13] Rather than timid or prudent, his conduct becomes altogether reprehensible in Dreyer's inaccurate version: "Kepler spoke to him [Reimers] at Prague in January, 1600, without revealing his own name" (*Tycho Brahe*, p. 304). But Kepler's own report plainly says: *Sicque nomen tandem professus pacifice ab ipso discessi* (FI, 237).

[14] TVIII, 352.16-23.

[15] FI, 282. The only favorable reference to Reimers in the critique—that although no astronomer, he was something of a mathematician—did not reappear in the memorandum prepared for Tengnagel, as was natural enough under the circumstances (A, p. 41.1104-8, p. 42.1126-28).

[16] TVIII, 299.34-40.

[17] FVIII, 729-30; Caspar and Dyck, *Briefe*, I, 126-29.

[18] FVIII, 715, 731.

[19] We know of this letter from Tycho's reply to it (TVIII, 343.25-27). Although presumably written late in July or early in August, 1600, it is incorrectly placed at the end of June by Anschütz (A, pp. 93-94, note to 1.997). Between June 1 and August 28, Kepler wrote twice to Brahe from Graz. The first of these letters was dispatched at the end of June (TVIII, 340.19), but it was in the second letter that Kepler announced his forthcoming refutation of Reimers (TVIII, 342.7-8, 343.22; FI, 231-32).

[20] FI, 217-18. Frisch accepted an incorrect date for Reimers' death (FI, 218), even though he himself published, on a later page, Brahe's reference to the exact date (FI, 232).

[21] TVIII, 352.23-30. The motivation of Tycho's request was completely misunderstood by Anschütz, who imagined that Brahe wished to check on Kepler's veracity and trustworthiness (A, p. 94, note to 1.997). Anschütz was misled by Frisch's gratuitous supposition that Herwart's (then unknown) response to Brahe's communication of August 28, 1600, perhaps aided in restoring Tycho's confidence in Kepler (FI, 232). But there is in fact no indication of any rift between them over Reimers, after they patched up their quarrel in April, 1600. Clearly, Brahe wanted either the original or an authenticated true copy of the critique, so that nobody could accuse him of falsifying a statement by Kepler, or of publishing it without proper authorization. On September 11 Herwart sent him the desired extract (TVIII, 354.36-357.11), with one or two unimportant or discreet modifications of Kepler's original (A, p. 38.997-p.41.1102).

[22] TVIII, 343.27-32; 343.41-344.2; 344.7-15.

[23] TVIII, 344.2-4. Only a few copies seem to have survived. Frisch evidently never saw the work; otherwise he would not have said that Kepler's letter was prefixed to it (FI, 219). In this regard he simply reproduced the false impression which Maestlin had somehow acquired without any first-hand acquaintance with the volume (FI, 232). Frisch overlooked the fact that whereas Maestlin used the word *praefixit*, Kepler wrote *inseruit* instead (FI, 234, 236). Now shortly after Frisch's death Anschütz discovered and edited a statement by Kepler which makes it perfectly clear that Reimers did not station the letter as a separate document in the front of his book, but rather incorporated it in the development of his argument (A, p. 37.936-37). Yet instead of utilizing Kepler's statement to correct Frisch's error, Anschütz repeated it (A, p. 6; p. 91, note to 1.931). For he was baffled by Kepler's citation of the page-number within the signature (*pagina D, fol. 1; cf.* the accompanying illustration)—a common

custom before printers generally adopted the practice of numbering the pages of a book consecutively (A, p. 38, note to 1.1004).

[24] FVIII, 734, 737.

[25] FI, 237.

[26] FVIII, 738. The date given by Frisch for Brahe's death was wrong (FI, 235; *cf.* FI, 312 and Dreyer, *Tycho Brahe*, p. 312). His defective grasp of the chronology led him astray on related questions (see n. 29, below).

[27] FI, 235.

[28] FI, 236-76.

[29] FI, 235; Frisch's error was induced by his false date (1601) for Kepler's removal from Graz to Prague. Yet at FI, 312 he himself published Kepler's statement that the transfer was accomplished in 1600 (*cf.* FVIII, 715).

[30] FVIII, 738.

[31] FI, 236.

[32] FVIII, 672.

[33] As does Max Caspar, *Bibliographia Kepleriana* (Munich, 1936), p. 121, followed by C. Doris Hellman, *The Comet of 1577* (New York, 1944), p. 164.

[34] FVIII, 738; Caspar and Dyck, *Briefe*, I, 152.

[35] FVIII, 738; Caspar and Dyck, *Briefe*, I, 240.

[36] FVIII, 740, 745.

[37] FVIII, 742.

[38] FI, 217, 235, 276.

[39] Frisch's reference (FVIII, 742) to further work on the *Defense* after August, 1601, is wholly gratuitous and in conflict, besides, with Kepler's own statement, as quoted above (see n. 35).

[40] Dreyer knew this to be the case (*Tycho Brahe*, p. 304, top); yet, probably out of excessive reliance on Frisch's authority, he assigned the composition to 1601 (*Tycho Brahe*, p. 304, bottom; TI, XLII). Pierre Duhem was content with either 1600 or 1601; see his ΣΩΖΕΙΝ ΤΑ ΦΑΙΝΟΜΕΝΑ, *Essai sur la notion de théorie physique de Platon à Galilée* (Paris, 1908), pp. 79, 122, reprinted from *Annales de philosophie chrétienne*, **156**, 484, 574, 1908. But the winter of 1600-1601 was correctly designated by Siegmund Günther, "Die Kompromiss-Weltsysteme des XVI, XVII und XVIII Jahrhunderts," *Annales internationales d' histoire*, Congrès de Paris, 1900 (Paris, 1901), V, 125.

COLLEGE OF THE CITY OF NEW YORK.

Sunspots, Weather, and your Radio*

By SIR HAROLD SPENCER JONES, F.R.S.

Recently an unusually large group of sun-spots developed on the sun. It has been easily visible to the naked eye when the sun was viewed through a heavily smoked glass or where its light was dimmed by haze or thin cloud, and its passage across the sun's disc, due to the rotation of the sun, has been readily apparent.

This group of spots, with an area of about 6,000,000,000 square miles, is the largest ever recorded at Greenwich.

What exactly is a sun-spot? It is a gigantic funnel-shaped vortex in the outer regions of the sun. Around the vortex intensely hot gases from within the sun whirl spirally upwards. As the gases stream out of the funnel-shaped mouth of the vortex, the pressure which has urged them upwards is released; they expand rapidly and are considerably cooled as a result. The region of the sun-spot, though tremendously hot, is therefore cooler than the rest of the sun's surface.

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It is purely by contrast with the much brighter surrounding surface that the spots appear dark; they are really very bright. The whirling motion of the heated gas gives rise to intense magnetic fields, comparable in strength to the field between the poles of a powerful dynamo.

The frequency of appearance of sun-spots waxes and wanes in cycles of about 11 years. The sun has passed through a quiet period during the past few years and sun-spots have been of infrequent occurrence.

But the sun has never been asleep; there have always been flickers of activity. Now it is arousing itself and a rapid increase in the number of sun-spots during the next three or four years can be regarded as certain.

But we cannot forecast when a big spot may appear. Many years may elapse before another spot as large as the present one will appear.

This great spot has come at a time of unusually stormy weather here. It is natural to associate the two phenomena and to attribute the storminess to the spot. But this is wrong. Another large spot may come at a time of fair weather.

Many attempts have been made to relate the waxing and waning of sun-spot activity with weather phenomena—temperature, rainfall cloudiness, and so on—but with little success.

That there is a connection is undoubted, but the effects are singularly small and the weather is such a complicated thing that the dependence upon sun-spots is usually smothered by a host of other factors.

If the sun never had any spots we should still have droughts and deluges; we should still have good harvests and bad. We must not blame the sun-spots for the recent widespread droughts and poor harvest. It is curious that the effect of the changing sun-spot activity is most clearly shown in the spacing of the annual rings of certain trees.

In the arid regions of Arizona and New Mexico the spacing between the rings is greater when sun-spots are numerous than when they are few. Dr. Douglass was able to use this fact to date the ruins of Pueblo Bonito, the largest of the great Indian communities in Chaco Canyon, New Mexico.

The spacing of the tree-rings depends upon an integrated effect of a variety of factors, such as the amount of rainfall and its distribution through the year, the temperature changes, and the amount of sunshine.

Certain phenomena associated with sun-spots do give rise, however, to marked effects on the earth. There is frequently seen to occur, in the vicinity of a spot, an intensely bright eruption, termed a solar "flare," as though a part of the outer layer of the sun is torn away, revealing the intensely heated interior.

Coincident with this comes a sudden fade-out on short-wave radio reception over the sunlit half of the earth, caused by the great increase

in ultraviolet radiation from the sun. There have been several of these flares and radio fade-outs lasting from about half an hour to two hours, during the past week.

At the same time, matter is shot out from the sun at an intensely high speed of about 1,000 to 1,500 miles a second. This matter is in the form of electrically charged particles, and when these encounter the earth, some 18 to 30 hours after being shot out from the sun, they come under the influence of the earth's magnetism and are drawn spirally inwards towards the North and South Magnetic Poles.

They then give rise to magnetic storms when the compass needle oscillates violently and telegraphic and telephonic communications are apt to be upset; vivid displays of aurora may also occur and interference be caused to radio communications.

A magnetic storm, associated with the large sun-spot, began one morning recently, and bright displays of the aurora are reported to have been seen during that night in various parts of the country where the skies were clear.

A phenomenon of great interest associated with sun-spots, only recently discovered, is a persistent hissing sound when receiving radio on a wave-length of a few metres during periods of marked solar activity.

It has been very noticeable recently, and indicates an abnormally large increase of electro-magnetic radiation from the sun in the vicinity of the spot. What the cause of this may be is not yet understood.

During the next few years we may look for increasing interference with radio transmission, more frequent fade-outs, more magnetic storms, more aurorae, and more frequent hissing on short-wave radio reception, all associated with the general increase in the sun's activity and accompanying the increase in the number of sun-spots.

April, 1946.

On a Critical Test for the Presence of a Lunar Atmosphere

By G. HERZBERG

In a recent note in this journal Khan[1] has discussed the possibility of obtaining a very critical test of the presence of a lunar atmosphere by trying to observe in the spectrum of the earth-shine characteristic features of an aurora. It may be of interest to record here some negative results and preparations for further work which also had the aim of detecting a very tenuous lunar atmosphere and which were based on considerations somewhat related to those of Khan.

While an auroral luminosity as suggested by Khan was also considered by the writer it is believed that *fluorescence radiation* on the

illuminated side of the moon will supply a much more critical test. Such fluorescence will produce a corona around the moon in much the same way that a head is formed by the gases emanating from the nucleus of a comet. Indeed cometary material in the form of meteors is constantly being deposited on the moon and on being heated by the sun it should give off gases similar to those in a comet (and to those given off by meteorites in the laboratory when heated under vacuum). If this be so the only reason why such a fluorescence has not as yet been discovered is that unlike in comets the radiation from the "nucleus," that is, the lunar disc, is so much stronger.

Spectrograms were therefore taken with the 12-inch telescope of the Yerkes Observatory as well as with the McDonald telescope with the slit just off the lunar disc. These should show the fluorescence radiation if it has sufficient intensity. However thus far light from the disc scattered by the atmosphere did not allow sufficiently long exposure times. In no case were the atmospheric conditions perfect, and no special precautions were taken to avoid stray light produced in the telescope.

A still more sensitive method of detecting this fluorescence radiation would be the application of the same method that is applied to the solar corona, that is, the use of a coronagraph. Through the kind cooperation of Dr. D. H. Menzel and Dr. W. O. Roberts preparations are being made for such observations with the coronagraph of Harvard College Observatory at Climax, Colorado.

Since the composition of the lunar atmosphere is here assumed to be similar to that of the head of a comet rather than to that of the earth as assumed by Khan, the spectrum of the fluorescence would be expected to be similar to cometary spectra. Even if the auroral spectrum of the lunar atmosphere could be obtained in the way outlined by Khan it seems unlikely that it would be found similar to the auroral spectrum of the earth as Khan assumes.

The present upper limit for the mass of a vertical column of unit cross-section in the lunar atmosphere is 10^{-6} times that of the earth.[2] If the experiments outlined above fail to give positive results they would set the upper limit for the density of the lunar atmosphere at the density in the heads of comets. An upper limit for the latter according to Wurm[3] is 10^{-9} atm., but the actual value is probably much smaller.

REFERENCES

[1] M. A. R. Khan, *P. A.*, **54**, 312, 1946.
[2] V. G. Fessenkoff, *Astron. J. Soviet Un.*, **20**, No. 2, p. 1, 1943. (Compare O. Struve, *Ap. J.*, **100**, 104, 1944.)
[3] K. Wurm, *V. J.*, **78**, 18, 1943.

YERKES OBSERVATORY, WILLIAMS BAY, WISCONSIN.

The Planets in November, 1946

By LELAND E. CUNNINGHAM

NOTE: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac*.

Sun. The sun will move slowly southward, and at the end of the month will be within two degrees of its southernmost declination.

On November 23 there will be a partial eclipse of the sun visible throughout the United States, except the extreme southwestern part, and Canada. The greatest magnitude (fraction of the sun's diameter hidden by the moon) will occur along the Atlantic seaboard, where the eclipse will begin about 11 A.M., and end about 2 P.M., E.S.T.; the magnitude will range from 0.64 at Orono, Maine, to 0.31 at Tallahassee, Florida. Magnitudes at some mid-western and western locations are: Chicago, 0.43; New Orleans, 0.22; Kansas City, 0.31; Denver, 0.18; Salt Lake City, 0.11; and Portland, Oregon, 0.08. The southern limit of the eclipse runs northwestward from a point near El Paso, and enters the Pacific ocean near the northern boundary of California.

The principal scientific value of a partial solar eclipse is the opportunity it affords to determine a very accurate position of the sun. The brilliancy and heat of the sun, daytime poor seeing, and inadequate comparison stars, render meridian circle observations of the sun less accurate than for any other object, and more subject to annoying systematic errors. The position of the moon, on the other hand, can be determined with high accuracy through observation of a large number of occultations each month. Comparisons of the positions of sun and moon at the times of solar eclipses then provide occasional accurate positions of the sun, and these help to eliminate the systematic errors from meridian circle positions.

Observers having access to a moderately long-focus telescope, and to accurate time, can greatly assist in the determination of the sun's position by observing photographically the times of first and last contacts. Photographs should be taken in rapid succession immediately following first contact, and immediately preceding last contact. Careful measurement of the length of the chord joining the cusps on each photograph, and the accurate times of the beginnings and endings of the exposures, provide the data needed to determine the instant of a contact. If possible, both contacts should be observed.

Moon. The phases of the moon will occur as follows:

		C.S.T.
First Quarter	November 1	11 P.M.
Full Moon	9	1 A.M.
Last Quarter	15	5 P.M.
New Moon	23	11 A.M.

Evening and Morning Stars. Throughout the month all the naked-eye planets except Saturn will be close to the sun. Venus will be an evening star at the beginning of the month, and a morning star at the end; it will be very near the horizon. Saturn will be a morning star near the meridian at sunrise.

Mercury. Mercury will have passed greatest elongation east on the last day

of October, but it will be too far south of the sun to be seen easily. At the beginning of the month it will be moving eastward about as rapidly as the sun, but will become stationary on the 11th, and then will move westward, or retrograde, for the remainder of November. It will meet the sun on the 21st, when it will be in inferior conjunction.

Venus. At the beginning of November, Venus will have just begun to retrograde, and will continue to do so throughout the month; it will meet the sun in inferior conjunction on the 17th. Because of its great brilliance it should be seen very low in the west just after sunset during the early part of the month, and very low in the east just before sunrise for the last few days of the month. During the daytime a small telescope should show the thin crescent very well.

Mars. Mars continues slowly to lose its eastward race with the sun. It will remain east of the sun, but too close to be seen.

Jupiter. Jupiter will be in conjunction with the sun on the last day of October, and by the end of November will become visible low in the east just before sunrise.

Saturn. On the first day of the month Saturn will be in quadrature with the sun, and will rise near midnight. It will then be moving slowly eastward in Cancer, but will become stationary on the 20th, after which date it will begin slowly to retrograde.

Uranus. Uranus will be retrograding in the western part of Taurus, and approaching opposition.

Neptune. Neptune will be a morning object in Virgo, but still rather too close to the sun for observation.

Students' Observatory, Berkeley, California, September 12, 1946.

Asteroid Notes

By HUGH S. RICE

Vesta. We have been observing the minor planet Vesta with Zeiss 50 mm this summer, and as usual have found it in its proper place in the sky, in agreement with the predicted ephemeris positions. The opposition date is September 22, at which time its distance from the earth is 131,130,423 miles, if we use the new value of 93,003,000 miles for 1 astronomical unit. The asteroid is still good for observation this autumn. It progresses in a retrograde direction along a course a few degrees south of Iota Ceti, and continues until about November 10, when it begins to resume its forward motion. The *Handbook of the British Astronomical Association* is seemingly in error in stating the entire course of the planet is in Cetus, because the western stationary point is over the border in Aquarius. Vesta's visual magnitude during the first week of November is about 7.9; hence it can be seen in a small telescope or even in binoculars. It may be brighter than 7.9, for the British computers indicate nearly a magnitude brighter; we have not made estimates of its magnitude, as yet.

At this apparition Vesta is none too easy to pick up—at first—inasmuch as the apparent path lies among inconspicuous stars; the key star however is the sparkling reddish-looking Iota Ceti. We say "apparition" purposely, as we are

trying to revive and perpetuate this technical term in astronomy. It is a good term and should be used more often, particularly with asteroids and comets. The word is defined correctly in Webster's "New International Dictionary," 2nd edition (under 4b), but this meaning is not found in Funk and Wagnall's "New Standard Dictionary." Another good term which seems to have fallen into disuse is *amplitude*. Here the definition is partly incorrect in Webster, but correct in Funk and Wagnall, as well as in Dutton's "Navigation and Nautical Astronomy." As a standard for the definition of terms like amplitude, etc., we refer to Chauvenet, "Spherical and Practical Astronomy."

For the subjoined ephemeris of asteroid no. 4, Vesta, we are indebted to the Yale University Observatory.

EPHEMERIS OF VESTA, FOR 0^h U.T.

1946	Equinox of Date R.A. h m	Dec. ° ′
Oct. 19	23 55.0	−12 50
23	23 52.8	−12 52
27	23 50.9	−12 50
31	23 49.5	−12 44
Nov. 4	23 48.4	−12 35
8	23 47.8	−12 23
12	23 47.7	−12 8

Aurora. On one night (Sept. 17, at 23^h E.S.T.), when we were about to observe Vesta and if possible Comet Giacobini-Zinner, we found the sky particularly bright. The region in Auriga covering the comet's position, and indeed most of the northern heavens were found to be covered with an aurora borealis. It was a nondescript, shapless manifestation, appearing exceedingly like low-lying clouds hanging, in its western parts, over the Hudson River. A long cloud-like formation extending over Cassiopeia was notable in that it would often disappear instantaneously and soon reappear, as if it were illuminated now and then by a giant searchlight. Considerable evidence of pulsation or "shivering" was noticed in this aurora. The phenomenon did not last much over 1^h.

Hayden Planetarium, American Museum of Natural History,
New York, N. Y., September 19, 1946.

Occultation Predictions for November, 1946

(Taken from the *American Ephemeris*)

Date 1946		Star	Mag.	IMMERSION Greenwich C.T.	*a*	*b*	Angle E from N	EMERSION Greenwich C.T.	*a*	*b*	Angle E from N
				h m	m	m	°	h m	m	m	°
OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′											
Nov.	1	56 B.Capr	6.3	20 59.4	−1.9	0.0	126	21 56.9	−1.6	+1.8	208
	2	37 Capr	5.8	23 23.8	−1.0	+1.8	19	0 23.5	−2.7	−1.1	290
	5	30 Pisc	4.7	20 56.2	−0.4	+3.0	3	21 27.4	−0.9	+0.5	304
	5	33 Pisc	4.7	22 32.4	−0.8	+2.1	38	23 39.1	−1.6	+1.2	260
	6	24 B.Ceti	6.0	1 43.6	−3.0	−0.7	108	2 28.7	0.0	+2.8	180
	7	26 Ceti	6.2	3 14.4	−1.8	+0.3	75	4 23.6	−0.9	+1.2	214
	12	412 B.Taur	6.0	1 16.7	0.0	+1.2	87	2 9.6	0.0	+1.6	246
	13	52 Gemi	6.0	6 38.0	−1.8	−0.5	119	7 45.4	−1.8	+1.7	241

OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′

Date 1944	Star	Mag.	IMMERSION Greenwich C.T.	IMMERSION *a*	IMMERSION *b*	IMMERSION Angle E from N	EMERSION Greenwich C.T.	EMERSION *a*	EMERSION *b*	EMERSION Angle E from N
			h m	m	m	°	h m	m	m	°
Nov. 2	37 Capr	5.8	22 59.5	..	..	0	23 25.6	−3.5	−2.6	322
3	143 B.Capr	6.2	4 16.5	−2.7	−3.8	126	4 46.5	+1.2	+3.2	177
5	33 Pisc	4.7	22 15.6	−0.4	+2.2	34	23 11.6	−1.0	+1.3	273
6	24 B.Ceti	6.0	1 1.4	−1.6	+1.2	79	2 11.3	−1.1	+1.8	212
7	26 Ceti	6.2	2 42.2	−1.3	+1.6	49	3 57.7	−1.6	+1.1	237
7	33 Ceti	6.2	7 14.9	−1.1	−0.4	71	8 19.1	−0.6	+0.2	228
13	52 Gemi	6.0	6 9.7	−1.2	+0.5	110	7 13.7	−1.1	+2.0	242
13	*A* Gemi	5.1	10 45.5	−2.1	+0.6	70	11 52.8	−1.1	−2.3	309

OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′

Nov. 3	143 B.Capr	6.2	3 14.3	−2.3	+0.2	76	4 37.1	−1.2	+0.6	226
5	336 B.Aqar	6.5	7 7.9	−0.6	+1.1	31	8 11.1	−1.0	−0.9	261
6	24 B.Ceti	6.0	0 24.4	−0.5	+1.7	65	1 30.1	−1.0	+1.8	239
7	26 Ceti	6.2	2 10.9	−0.3	+2.6	16	3 1.4	−1.7	+0.8	279
7	33 Ceti	6.2	6 32.7	−1.4	+1.4	42	7 47.9	−1.6	+0.3	244
7	*f* Pisc	5.3	11 8.9	−0.4	+0.6	39	12 0.8	−0.1	−1.1	270
13	52 Gemi	6.0	5 50.0	0.0	+1.2	84	6 46.8	−0.3	+1.2	264
13	*A* Gemi	5.1	9 45.3	−1.6	+1.0	83	11 4.7	−2.1	−0.1	278
30	33 Capr	5.5	1 59.8	−1.4	+0.8	44	3 19.0	−1.6	−0.7	260

OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +30° 0′*

Nov. 2	37 Capr	5.8	22 12.4	−1.8	+2.9	30	23 16.3	−2.5	−0.2	296
5	336 B.Aqar	6.5	7 24.3	−0.7	−0.7	82	8 20.6	0.0	+0.7	218
5	33 Pisc	4.7	21 53.3	−0.2	+1.7	54	22 52.9	−0.6	+1.4	256
6	24 B.Ceti	6.0	0 37.9	−1.7	+1.0	89	1 42.0	−1.0	+2.5	204
7	26 Ceti	6.2	2 15.8	−1.4	+1.7	57	3 32.4	−1.5	+1.7	227
7	33 Ceti	6.2	7 12.6	−2.2	−1.6	101	8 3.6	−0.5	+2.4	192
13	52 Gemi	6.0	6 1.7	−1.7	−1.2	137	6 41.6	0.0	+3.6	210
13	*A* Gemi	5.1	10 31.9	−2.3	−1.0	110	11 55.1	−2.1	−0.4	268
30	33 Capr	5.5	2 37.2	−1.9	−1.6	101	3 31.9	+0.3	+1.4	202

*Computed by Edgar W. Woolard and Paul Herget; communicated by Commodore J. F. Hellweg, Superintendent U. S. Naval Observatory.

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b;* apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

Comet Notes

By G. VAN BIESBROECK

Of the many comets observable at this time only one is accessible to small telescopes, namely, periodic COMET 1946 *d* (GIACOBINI-ZINNER) which has been followed since May 29. During August it has swept rapidly to within 10° of the pole and has now started on its southward motion. The ephemeris is continued here (*Harv. Ann. Card 756*):

1946	α h m	δ ° ′	Distance from earth	Distance from sun	Mag.
Oct. 3	6 55.2	+ 4 14	0.30	1.02	8.6
7	7 0.7	— 3 14	.32	1.03	8.9
11	4.9	— 9 35	.35	1.05	9.2
15	8.3	—14 57	.38	1.07	9.5
17	10.7	—19 30	.41	1.09	9.8
23	12.4	—23 22	.44	1.11	10.2
27	13.1	—26 40	.47	1.14	10.5
31	13.0	—29 30	.50	1.17	10.8
Nov. 4	7 12.0	—31 55	0.54	1.20	11.1

It shows that the comet will be visible in the second half of the night moving rapidly across the Milky Way in which it has been traveling during most of this apparition. In spite of the nearly full moon last night (September 12) I could pick up without difficulty the well-condensed coma and I estimated the total brightness as magnitude 8.2, in complete agreement with the prediction of the above ephemeris. We are now near perihelion (September 18) and near minimum distance from the earth and the brightness will soon begin to drop. Observers will be on the watch in the evening of October 10 for the Draconid shower of meteors expected then because the earth crosses the plane of the comet's orbit on that night.

Two new comets have been added to the already long list of objects found this year. Both, however, are visible only in the southern hemisphere so far.

COMET JONES. The first announcement was received August 9 through I. L. Thomsen (New Zealand) reporting the discovery of a 9 mag. comet by A. Jones of Timaru (New Zealand) as follows:

1946 August 6.7639 U.T. $7^h\,56^m.0$ 13° 15′, and

moving daily $+3^m\,0^s$ in right ascension and —15′ in declination. From unpublished further observations received through the same channel, L. E. Cunningham and Miss M. Stahr (Berkeley) have computed a preliminary parabolic orbit giving October 4.873 for the time of perihelion passage. In all probability this morning object will come in reach of the northern observers in the latter part of this year. Its brightness increases but for some time it will remain too close to the sun for observers on this side of the equator.

COMET BERRY. Also through I. L. Thomsen (New Zealand) came on September 10 the report of the discovery of another southern comet of magnitude 11 by Berry as follows:

1946		α h m	δ ° ′
Sept.	2.73854	9 24.4	—17 40
	3.74306	26.5	22 5
	4.73958	9 27.3	—24 12

Further precise observations are required in order to define the orbit and to predict the future course.

Of the comets discovered earlier in the year four are still under observation but all are decreasing in brightness. (1) COMET 1946 *a* (TIMMERS) appeared as a 12 mag. round coma on August 20 and showed a well-condensed nucleus. As shown by the ephemeris below it is expected to fade gradually as it moves in the evening sky and the period of visibility will come to a close before the end of the year. (2) COMET 1946 *b* (PERIODIC TEMPEL 2) remains observable in the

night. It appears as a large diffuse nebulosity losing slowly in brightness since its nearest approach in August. (3) COMET 1946 *e* (PERIODIC BROOKS) remains only accessible to large instruments, reaching maximum brightness about October 1. (4) COMET 1943 *a* (PERIODIC OTERMA) is still well situated but does not get brighter than magnitude 17.

In the morning sky watch should now begin on PERIODIC COMET SCHWASSMANN-WACHMANN 1925 II which shows such remarkable changes in brightness. It will come to opposition on December 29 and remain in good position through the winter.

EPHEMERIDES

	COMET TIMMERS				COMET TEMPEL 2			
	α	δ			α	δ		
	h m	° ′	Mag.		h m	° ′	Mag.
Oct. 3	17 27.7	+22 44	13.5	Oct. 3	1 26.2	−20 58	11.9
11	38.8	19 39	13.8	11	19.7	21 3	12.1
19	17 49.8	16 54	14.0	19	13.9	20 38	12.4
27	18 00.7	14 27	14.3	27	9.2	19 47	12.7
Nov. 4	18 11.5	+12 18	14.6	Nov. 4	1 6.2	−18 34	13.0

COMET 1925 II

	α	δ
	h m	° ′
Oct. 3	6 49.1	+30 21
11	50.7	25
19	51.6	29
27	51.8	35
Nov. 4	6 51.3	+30 41

Williams Bay, Wisconsin, September 12, 1946.

METEORS AND METEORITES

Contributions of the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

The Coördinate Numbers of the Falls of the U.S.S.R., Estonia, Latvia, Lithuania, and Poland*

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ABSTRACT

The coördinate numbers of the falls of the U.S.S.R., Estonia, Latvia, Luthuania, and Poland, taken from our "Catalog of Provisional Coördinate Numbers for the Meteoritic Falls of the World," are compared, in Tables 1 and 2, with the coördinate numbers derived from the longitudes and latitudes as given by E. L. Krinov for 112 of the 113 falls appearing in his "Short Catalog of the U.S.S.R. Meteorites" (1945). Six (6) falls listed by Krinov, but not found in the catalogs of Coulson, Hey, and Leonard, are enumerated in Table 3, while 14 falls

*Read at the Ninth Meeting of the Society, Flagstaff and Meteorite Crater, Arizona, 1946 September 9 and 10.

not listed by Krinov, but included in our catalog, are inventoried in Table 4. The data of Tables 1 and 2 are commented on briefly.

In the *Astronomical Journal of the Soviet Union,* **22**, No. 5, 303-11, 1945, appears a "Short Catalog of the U.S.S.R. Meteorites," published by E. L. Krinov of the Committee on Meteorites of the Academy of Sciences of the U.S.S.R., under date of July 25, 1945. Following is a free (rather than *verbatim*) quotation from a statement in English which is included on pp. 310-11:

"The lists of the U.S.S.R.'s meteorites published in the Russian and foreign publications are not quite correct. The present catalog corrects these errors. The materials of the Committee on Meteorites of the Academy of Sciences of the U.S.S.R. and various data published elsewhere have been used. The catalog contains 113 meteorites [falls] known before 1945 July 1 and found on the territory of the U.S.S.R. [and likewise on that of Estonia, Latvia, Lithuania, and a part of Poland].

"The catalog contains the accepted names of meteorites in the Russian and English transcriptions, the latter, with few modifications, having been taken from G. T. Prior's catalog of meteorites, London, 1923, and from the appendices to that catalog issued in 1927 and 1940. The longitude of the locality where the fall took place is reckoned from Greenwich. [Observed falls, unobserved falls (or finds), siderites, siderolites, and aerolites are designated by various symbols.] For the finds [unobserved falls] is given only the year of the find, while, for [the observed] falls, the complete date is given. For every meteorite [fall] are quoted the total number of individual specimens found, their combined [integrated] weight in kilograms, and the locality where the main mass is now present [preserved]. [The abbreviations used for the 17 depositories (in the U.S.S.R. and abroad) where specimens of the falls are on exhibition are then listed.]

"The meteorites [falls] represented in the collection of the Academy of Sciences of the U.S.S.R. are marked by a single asterisk, while those present only in this collection are marked by a double asterisk.

"At the end is given the distribution of meteorites [falls] among the Republics of the Union, according to [observed] falls, finds [unobserved falls], and types. The chart of finds of meteorites is added [on p. 304]. This shows evidently the dependence of the frequency of finds upon the density of population and the localization of shafts [= location of mine shafts?], where many iron meteorites have occasionally been found."

Krinov's catalog has been carefully compared with our "Catalog of Provisional Coördinate Numbers for the Meteoritic Falls of the World."[1] The results of that comparison are presented in the 4 accompanying—and largely self-explanatory—tables. In the column headings of the several tables, "P.C.N." stands for the provisional coördinate number (taken from our catalog), "C.N.(K.)" for the coördinate number composed of the coördinates as given by Krinov,[2] "K.N." for the serial number in Krinov's catalog, and "Cl." for the class of the fall. In the first 3 tables, the class is listed merely as A (aerolite), So (siderolite), or Si (siderite), while in Table 4 it is given usually in a more detailed form (as in our catalog). The falls are tabulated alphabetically by their common geographical names, but where these differ from the names employed by Krinov, the latter also are included, as synonyms, with cross references to the ordinary designations.

No attempt has been made, thus far, critically to compare the positional data

provided by Krinov with those previously obtained from other authorities. It is greatly to be hoped that the coördinates that he has supplied constitute the most accurate information now available on the locations of the falls of the Soviet Union. Unfortunately our knowledge of the positions of a considerable number of those falls—especially some in Siberia—has hitherto been seriously impaired by uncertainty. Further investigations will have to be made, however, before it can be determined to just what extent that uncertainty has been removed by the data of Krinov's catalog.

NOTES

[1] Now in press as *Univ. of New Mexico Publ. in Meteoritics*, No. 1, xiv + 54 pp., 1946, a monograph of the Institute of Meteoritics of the University of New Mexico and of the Society for Research on Meteorites.

[2] Krinov gives the geographical coördinates, longitude and latitude, each expressed to the nearest minute of arc, of all of the 113 falls enumerated by him with one exception only, namely Malyi Altai, which is no. 58 on his list.

TABLE 1. COÖRDINATE NUMBERS* OF THE FALLS OF THE U.S.S.R.

P.C.N.	C.N.(K.)	K.N.	NAME AND CL.	REMARKS
			1. EUROPEAN U.S.S.R.	
0319,511:*	*0318*,510	3	Alexandrovsky, A Alexandrovsky Khutor, *v.* Alexandrovsky	Syn.: Alexandrovsky Khutor
0597,496	*0295*,496	4	Andryushki, A	*V.* n. in Hey, *op. cit.*, n. (‡), *post*, under Andryushki, pp. 12-13.
0350,483	*0351*,481	2	Augustinovka, Si	
0380,484	*0380*,486	5	Bachmut, A Bakhmut, *v.* Bachmut	Syn.: Bakhmut
0367,468	*0368*,468	8	Berdyansk, A	Cl. given as Li:P? by A. L. Coulson†
0268,498	*0272*,501	7	Bielokrynitschie, A	
0301,498	*0302*,498	6	Bjelaja Zerkov, A	
0525,542	Same	95	Boriskino, A	Syn.: Staroje Boriskino
0357,555	*0359*,555	14	Borodino, A Borovaya, under "2. Asiatic U.S.S.R.," *post.*	
0363,516	*0339*,513	15	Botschetschki, A	
0302,519	*0304*,515	16	Brahin, So	
0376,567	*0376*,574	46	Glasotovo, A	Syn.: Kashin
0457,437	*0454*,437	23	Grosnaja, A	
0306,464	Same	24	Grossliebenthal, A	
0467,394	*0472*,401	37	Indarch, A Indarkh, *v.* Indarch	Syn.: Indarkh
0306,498	*0308*,499	41	Kagarlyk, A	
0532,554	Same	42	Kainsaz, A Kashin, *v.* Glasotovo	
0364,496	*0351*,506	31	Kharkov, A	Syn.: Žigajlowka
0323,548	*0354*,552	47	Kikino, A	
0507,553	*0509*,549	110	Kissij, A	Syn.: Tchuvashsky Kissy
0395,551	*0409*,540	48	Krasnoi-Ugol, A	
0318,510	*0317*,512	50	Kukschin, A Kukschino, *v.* Kukschin	Syn.: Kukschino
0327,507	*0335*,508	51	Kuleschovka, A	
0440,402	*0450*,411	52	Kulp, A	
0516,526	*0516*,524	53	Lavrentievka, A	
0336,521	*0328*,523	55	Leonovka, A	

P.C.N.	C.N.(K.)	K.N.	Name and Cl.	Remarks
0420,494	*0425*,491	57	Lipovsky, So	Syn.: Lipovsky Khutor
			Lipovsky Khutor, *v.* Lipovsky	
0350,485:	*0354*,473	112	Lyubimovka, A	Syn.: Yurtuk
0308,480	*0310*,481	60	Mighei, A	
			Mordvinovka, *v.* Pavlograd	
0375,550	*0352*,542	65	Netschaëvo, Si	
0438,560	*0438*,548	70	Novo-Urei, A	Syn.: Novy-Urei
			Novy-Urei, *v.* Novo-Urei	
0555,576	*0553*,578	75	Ochansk, A	Syn.: Okhansk
0293,490	*0315*,493	76	Oczeretna, A	Syn.: Otcheretna
			Okhansk, *v.* Ochansk	
			Otcheretna, *v.* Oczeretna	
0359,486	*0360*,485	62	Pavlograd, A	Syn.: Mordvinovka
0432,519	*0428*,520	77	Pavlovka, A	
0394,566	Same	81	Pervomaisky, A	Syn.: Pervomaisky Posiolok
			Pervomaisky Posiolok, *v.* Pervomaisky	
0437,482	Same	82	Petropavlovka, A	
0370,545	*0370*,530	85	Rakovka, A	
0457,486	Same	86	Repeev Khutor, Si	
			Retchki, *v.* Ryechki	
0355,500	*0345*,511	87	Ryechki, A	Syn.: Retchki
			Saratov, *v.* Saratov Govt.	
0458,515	*0468*,525	90	Saratov Govt., A	Syn.: Saratov
0445,484	*0348*,485	91	Sarepta, Si	
0300,469	*0299*,472	89	Savtschenskoje, A	
0365,505	*0366*,506	92	Sevrukovo, A	
			Slobodka, *v.* Slobodka (1)	
0317,556A	*0348*,549	93	Slobodka (1), A	Syn.: Slobodka
			Staroje Boriskino, *v.* Boriskino	
0420,450	Same	94	Stavropol, A	
			Tchuvashsky Kissy, *v.* Kissij	
0352,548:	*0352*,547	102	Timochin, A	Syn.: Timokhina
			Timokhina, *v.* Timochin	
0350,477	*0348*,478	103	Tomakovka, A	
0327,466	*0328*,462	20	Vavilovka, A	
0431,484	*0432*,484	22	Verkhne Tschirskaia, A	
			Yurtuk, *v.* Lyubimovka	
			Zaboritza, *v.* Zaborzika	
0279,504	*0277*,503	34	Zaborzika, A	
0372,476	Same	33	Zhovtnevyi, A	Syn.: Zhovtnevyi Khutor
			Zhovtnevyi Khutor, *v.* Zhovtnevyi	
			Zigajlowka, *v.* Kharkov	
0283,527	*0268*,518	32	Žmenj, A	

2. Asiatic U.S.S.R.

P.C.N.	C.N. (K.)	K.N.	Name and Cl.	Remarks
0900,530:	*0914*,538	1	Abakan, Si	According to L. J. Spencer, this may be a part of the Toubil River fall, *post*.
			Andryushki, under "1. European U. S. S. R.," *ante*.	
0837,534	*0841*,527	100	Barnaul, A	Syn.: Teleutskoje Ozero
0601,476	*0622*,520	9	Bischtübe, Si	
1136,586	*1142*,578	11	Bodaibo, Si	
1312,465	*1316*,446	10	Boguslavka, Si	
0381,490	*0942*,587	13	Borovaya, Si	Prob. = the dtfl. Angara (for which P. C. N. = *0921*,586:), Murozhnaya, and Uderei; *v.* n. in Hey, under Angara, p. 13‡.
0593,521	Same	17	Brient, A	
0852,529	*0848*,515	25	Demina, A	
0740,539	*0701*,533	29	Dorofeevka, Si	
1041,510	*1123*,512	28	Doroninsk, A	
0704,519	Same	30	Erofeevka, A	
0829,582	Same	39	Ichkala, A	Syn.: Itchkala
			Itchkala, *v.* Ichkala	
0737,424	*0734*,424	43	Kaptal-Aryk, A	
0595,541	*0579*,511	44	Karagai, A	
0807,480	*0810*,472	45	Karakol, A	
0752,568	*0753*,568	107	Khmelevka, A	
0930,540:	*0914*,560	80	Krasnojarsk, So	Syn.: Pallas Iron
0753,552	Same	49	Kuznetzovo, A	
1254,560	Same	54	Lebedinnyi, Si	Syn.: Lebedinnyi Priisk
			Lebedinnyi Priisk, *v.* Lebedinnyi	
0852,500	?	58	Malyi Altai, So	Poss. = Pavlodar (1), *post*
			Mamra, *v.* Mamra Springs	
0630,433	*0621*,452	59	Mamra Springs, A	Syn.: Mamra
0638,583	*0942*,587	63	Murozhnaya, Si	Prob. = the dtfl. Angara, Borovaya, and Uderei; *v.* n. in Hey, under Angara, p. 13‡.
1118,511	*0786*,524	66	Nikolaevka, A	
			Niro, *v.* Verkhne Udinsk	
1156,611	*1176*,600	72	Nochtuisk, Si	Syn.: Nokhtuisk
			Nokhtuisk, *v.* Nochtuisk	
			Norin-Schibir, *v.* Norin-Shibir	
1079,508	*1079*,518	71	Norin-Shibir, Si	Syn.: Norin-Schibir
0712,519	Same	68	Novorybinskoe, Si	
0760,570:	*0768*,560	74	Orlovka, A	
			Pallas Iron, *v.* Krasnojarsk	
			Pavlodar, *v.* Pavlodar (2)	
0770,525A	*0773*,518	113	Pavlodar (1), So	Syn.: Yamysheva
0770,525B	*0770*,523	78	Pavlodar (2), A	Syn.: Pavlodar
0661,555	Same	96	Pesyanoe, A	Syn.: Staroje Pesyanoe
0614,610	*0872*,234	83	Petropavlovsk, Si	Syn.: Petropavlovsky Priisk
			Petropavlovsky Priisk, *v.* Petropavlovsk	
0921,586:	*0989*,586	98	Ssyromolotovo, Si	

			Staroje Pesyanoe, *v.* Pesyanoe	
1332,449	Same	97	Sungach, A	Syn.: Sungatch
			Sungatch, *v.* Sungach	
1297,511	*1074*,514	99	Tarbagatai, A	
			Teleutskoje Ozero, *v.* Barnaul	
0900,564	*0891*,559	104	Toubil River, Si	Syn.: Tubil
1026,512	*1025*,517	105	Tounkin, A	Syn.: Tunka
			Tubil, *v.* Toubil River	
			Tunka, *v.* Tounkin	
0936,588	*0944*,587	106	Uderei, Si	Prob. = the dtfl. Angara, Borovaya, and Murozhnaya; *v.* n. in Hey, under Angara, p. 13‡.
1075,520	*1140*,548	67	Verkhne Udinsk, Si	Syn.: Niro
			Yamysheva, *v.* Pavlodar (1)	

NOTES TO TABLE 1

*A coördinate number followed by a colon is uncertain or of low accuracy, while one followed by both a colon and a star (as, *e.g.*, in the case of Alexandrovsky) is the coördinate number of the capital city (or town) of the *smallest* political subdivision in which the fall is known to have occurred.

†Coulson, A. L.: "A Catalogue of Meteorites," *Mem. Geol. Surv. India*, **75**, 48, 1940.

‡Hey, M. H.: "Second Appendix to the Catalogue of Meteorites. . . British Museum (Natural History)," 1940. Since Angara, Borovaya, Murozhnaya, and Uderei are all sideritic (Si) falls of the same date (1885), they constitute, almost certainly, one and the same fall, of which the coördinate number may be taken to be *0942*,587 (*cf.* the identical, or practically identical, C.N.(K.)'s of Borovaya, Murozhnaya, and Uderei). Borovaya, Murozhnaya, and Uderei are listed merely as synonyms for Angara by Coulson, *op. cit.*, n. (†), *ante*, p. 37, who, following Prior, records Angara as "doubtful." Angara is not even referred to by Krinov, and it is included in our catalog only as a bracketed (*i.e.*, doubtful) fall. No suggestion can be made here as to which of the 4 previously mentioned names would be the most appropriate one to adopt for the fall of which the coördinate number seems to be *0942*,587.

TABLE 2. COÖRDINATE NUMBERS OF THE FALLS OF ESTONIA, LATVIA, LITHUANIA, AND POLAND

P.C.N.	C.N.(K.)	K.N.	NAME AND CL.	REMARKS
			1. ESTONIA	
0227,584	*0228*,584	40	Kaalijärv, Si	
			Oesel, *v.* Oesel Island	
0230,585	Same	111	Oesel Island, A	Syn.: Oesel
0257,587	*0255*,580	84	Pillistfer, A	
0270,580	Same	101	Tennasilm, A	
			2. LATVIA	
			Buschhof, *v.* Buschof	
0258,564	Same	19	Buschof, A	Syn.: Buschhof
0265,559	*0264*,560	56	Lixna, A	
0220,570:B	*0230*,567:	61	Misshof, A	
0220,570:A	*0215*,565:	64	Nerft, A	
			3. LITHUANIA	
0244,557	*0243*,550:	38	Jodzie, A	
0262,557:*	*0220*,560	69	Novy-Projekt, A	
0281,551	*0253*,558	79	Padvarninkai, A	
0253,543	*0269*,537	35	Zabrodje, A	
0250,553	Same	26	Žemaitkiemis, A	

P.C.N.	C.N.(K.)	K.N.	Name and Cl.	Remarks
			4. Poland	
			Dolgaja Volja, *v.* Dolgovoli	
0253,507	*0253,508*	27	Dolgovoli, A	Syn.: Dolgaja Volja
0257,501	*0255,500*	73	Okniny, A	
0253,530	*0245,528*	88	Ruschany, A	Dtfl.

TABLE 3. FALLS LISTED BY KRINOV BUT NOT FOUND IN OTHER CATALOGS†

C.N.(K.)	K.N.	Name and Cl.	Date of Fall or Find
		1. European U.S.S.R.	
0574,512	36	Ilinskaya Stanitza, Si	Fd. 1915
0340,518	109	Tchervony Koot, A	Fl. 1939 June 23
		2. Asiatic U.S.S.R.	
0834,576	12	Bolshaja Korta, A	Fd. 1939
1375,664	18	Burgavli, Si	Fd. 1941
0880,537	108	Tchebankol, Si	Fd. 1938
0973,538	21	Velikonikolajevskyi Priisk, Si	Fd. 1902

Note to Table 3

†Coulson's, Hey's, and Leonard's.

TABLE 4. FALLS NOT LISTED BY KRINOV†

P.C.N.	Name and Cl.	Remarks
	1. European U.S.S.R.	
0376,558:B	Agricultural College, Ha	Place of fall unkn.; C.N. for Moscow
0407,455	Kavkaz, C	C.N. for Kavkassk (= Kropotkin)
0313,586:*	Novo-Ergi, Novgorod Govt., A	
0484,544	Simbirsk, Ck	
*0317,556*B	Slobodka (2), Cwa	Poss. = Slobodka (1), Cc
0376,558:A*	Tennant's Iron, Og	Place of fall unkn.; C.N. for Moscow
0343,487	Verkhne Dnieprovsk, Off	
	2. Asiatic U.S.S.R.	
0968,569	Biryusa, O	
0900,520:	Chinga, D_1	Place of fall in Mongolia
1019,609	Podkamennaya Tunguska, Si?	No meteoritic material recovered
	3. Poland	
0232,531	Bialystok, Ho	
0199,520	Lowicz, Msg	
0211,527	Pultusk, Cga	
0184,534	Schwetz [Swiecie], Om	

Note to Table 4

†But included in Leonard's catalog.

E. Blackwelder on the Origin of the Arizona Meteorite Crater

After noting (*C.S.R.M.*, **3**, 249; *P. A.*, **54**, 152-3, 1946) the "reactionary" opinion expressed by N. H. Darton under the caption of "Crater Mound, Arizona," it is gratifying to read the following letter, entitled "Meteor Crater, Arizona," by a man of the geological eminence of Professor Eliot Blackwelder of Stanford University. The letter, which appeared in *Science*, **104**, 38-9, 12 July 1946, is herewith quoted in full:

"In December, 1945, Nelson H. Darton restated to the Geological Society

of America, and also to the Association of American Geographers, his belief that Meteor Crater, east of Flagstaff, on the Arizona Plateau, is of volcanic rather than meteoritic origin. He cited a decision of the U.S. Board on Geographic Names in which the name *Crater Mound* was officially adopted, and he urged that the use of the term *Meteor Crater* be discontinued. Since notices of Mr. Darton's views have been published in *Science News Letter* and other nontechnical media, it seems timely to indicate that the majority of geologists, astronomers, engineers, and others who have studied the Crater disagree with Mr. Darton and are convinced that the Crater was made by the impact of a large meteorite.

"Mr. Darton appears to stake his opinion largely on the failure of exploration (by drilling and geophysical methods) to reveal the presence of a buried meteorite beneath the Crater. He is perhaps not aware that in 1930 F. R. Moulton showed that if a large meteorite did strike the plateau, it must have developed at the point of impact such a high temperature as to result not only in a tremendous explosion but also in vaporization of the meteorite itself, along with part of the surrounding rock strata. Under those circumstances one could not expect now to find more than incidental fragments of the meteorite.

"Mr. Darton also seems to ignore the significance of the unique composition of the parapet which surrounds the Crater and the material which partially fills the cavity itself. He is perhaps unaware that underneath the surface rubble these consist largely of quartz powder and silica glass, derived from the underlying sandstone by pulverizing and melting. No materials of this kind have ever been found in association with volcanoes, and temperatures high enough to produce silica glass are probably rarely, if ever, attained in volcanic eruptions.

"It seems, therefore, that the current use of the name *Meteor Crater* is well justified, and the field evidence is heavily against the hypothesis of volcanic origin."

The only thing that we have to add to this, other than a hearty amen, is our often reiterated recommendation that the Crater be called—for obvious reasons—*Meteorite* rather than *Meteor Crater!*—F.C.L.

A Recent Observed Achondritic Fall Near Marathon, Texas: Pena Blanca Springs

In *Texas Observers' Bulletin* for 1946 August, p. 1, the editor, Mr. Oscar E. Monnig, of Fort Worth, writes: "Thru the courtesy and coöperation of Dr. Gayle Scott of the Department of Geology of Texas Christian University, we were promptly informed of the fall of a meteorite near Marathon, Brewster County, Texas, on August 2, shortly after noon. Dr. Scott and a party of geology students on a field trip were south of Marathon and heard the detonations. Mr. H. H. Morse of Fort Worth, and your editor, made a 5-day trip of investigation, definitely identified the meteorite, and assisted in additional recoveries, bringing the total material retrieved from the fall up to about 155 pounds. Marked detonations were heard over about the usual area, but to date no definite observations of the fireball itself have been reported, nor was any dust or 'smoke' cloud seen. The meteorite is an achondrite with very low metallic-iron content, and the crust is consequently not black; instead, the surface melt is at most a gray and is actually a creamy white in many portions. No locality designation has yet been definitely assigned to it. [Mr. Monnig has since assigned the name Pena Blanca Springs, Brewster County.]

"The writer hopes to present a preliminary paper on this fall at the meeting of the Society for Research on Meteorites which is scheduled for Flagstaff [and Meteorite Crater], Arizona, September 9-10. . ."

The coördinate number of Pena Blanca Springs, according to Mr. Monnig, is 1031,301.

Personnel of the Commission on Meteors etc. of the I.A.U.

In *Circular* VI, 2, of the International Astronomical Union, issued 1946 July 4, the personnel of Commission 22, that on Meteors, the Zodiacal Light, and Similar Problems, is announced as follows (p. 16):

President: Whipple; *Members:* Astapovich, Bečvář, Bosler, Cap, Chant, M. Davidson, Dobson, N. Donitch, Dufay, Elvey, J. W. Evans, Fedynsky, Fesenkov, Mme. Flammarion, Gatterer, Guth, Harang, Housman, Kaplan, Kopal, Leonard, Link, Millman, Nielsen, Nininger, Olivier, Porter, Prentice, V. M. Slipher, Störmer, Vandekerkhove, and Watson.

The personnel of the Subcommission on the Zodiacal Light and the Light of the Night Sky (p. 17) consists of:

President: Dufay; *Members:* Horace W. Babcock, Bousfield, Cabannes, Cap, S. Chapman, Dauvillier, N. Donitch, Elvey, Fesenkov, Gauzit, Harang, Housman, Link, V. M. Slipher, Störmer, Struve, and Vegard.

The Council of the Society for the 1946-50 Term

At the Ninth Meeting of the Society, held at Flagstaff and Meteorite Crater, Arizona, on September 9 and 10, 1946, the following members of the Council (Officers and Councilors) were elected for the 1946-50 term, which commenced at the adjournment of the meeting on September 10:

President: Dr. Arthur S. King, Mount Wilson Observatory, Pasadena, California

Vice-Presidents: Dr. F. R. Moulton, Smithsonian Institution Building, Washington, D. C.

Dr. Charles P. Olivier, Flower Observatory, University of Pennsylvania, Upper Darby

Dr. L. J. Spencer, 111 Albert Bridge Road, London, S. W. 11, England

Secretary: Mr. Oscar E. Monnig, 1010 Morningside Drive, Fort Worth, Texas

Treasurer: Mr. L. F. Brady, 922½ Forest Avenue, Tempe, Arizona, and Museum of Northern Arizona, Flagstaff

Editor: Dr. Frederick C. Leonard, University of California, Los Angeles

Councilors:

Mr. John Davis Buddhue, 99 South Raymond Avenue, Pasadena, California

Dr. C. H. Cleminshaw, Griffith Observatory, Los Angeles, California

Dr. Lincoln La Paz, University of New Mexico, Albuquerque [Dr. La Paz, as President during the 1941-46 term, is *ex-officio* Councilor during the 1946-50 term.]

Professor Earle G. Linsley, Chabot Observatory, Oakland, California

Dr. Howard A. Meyerhoff, Smith College, Northampton, Massachusetts

Dr. Stuart H. Perry, Adrian, Michigan

Professor J. Hugh Pruett, University of Oregon, Eugene

Dr. Fred L. Whipple, Harvard College Observatory, Cambridge, Massachusetts

The Name of the Society Changed to "The Meteoritical Society"

Sections 1 and 2 of Article 1 (entitled "Name, Purpose, and Scope") of the Constitution of the Society were amended at the Ninth Meeting, held at Flagstaff and Meteorite Crater, Arizona, on September 9 and 10, 1946, to read as follows:

"Sect. 1. The name of this Society shall be THE METEORITICAL SOCIETY.

"Sect. 2. The purpose of this Society shall be to promote the discovery, collection, investigation, and preservation of meteorites; to forward the observation and study of meteors and other meteoritical phenomena; and generally to advance meteoritics and related sciences thru the increase and diffusion of knowledge concerning meteorites and meteors."

These amendments went into effect at the adjournment of the meeting on September 10; whereupon the name of the Society was officially changed from "The Society for Research on Meteorites"—the name under which our organization has been operating since its inception in 1933—to "The Meteoritical Society."* (It is hardly necessary to add that *meteoritical* is merely the adjective of *meteoritics*, defined as "the science of meteorites and meteors." The new name is not only much shorter than the old one, but also more appropriate, in view of the objects of the Society as set forth in Art. 1, Sect. 2, of its Constitution, as now amended.)

Other amendments to the Constitution and the Bylaws of the Society that were adopted at the Ninth Meeting and that became effective upon its adjournment will be published in the next issue of these CONTRIBUTIONS.

President of the Society: ARTHUR S. KING, Mount Wilson Observatory, Pasadena 4, California

Secretary of the Society: OSCAR E. MONNIG, 1010 Morningside Drive, Fort Worth 3, Texas

*The name will not be *legally* changed until the Articles of Incorporation also are revised; accordingly, these CONTRIBUTIONS will continue to be styled *C.S.R.M.* until the end of the year 1946, when Vol. 3 will be concluded.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

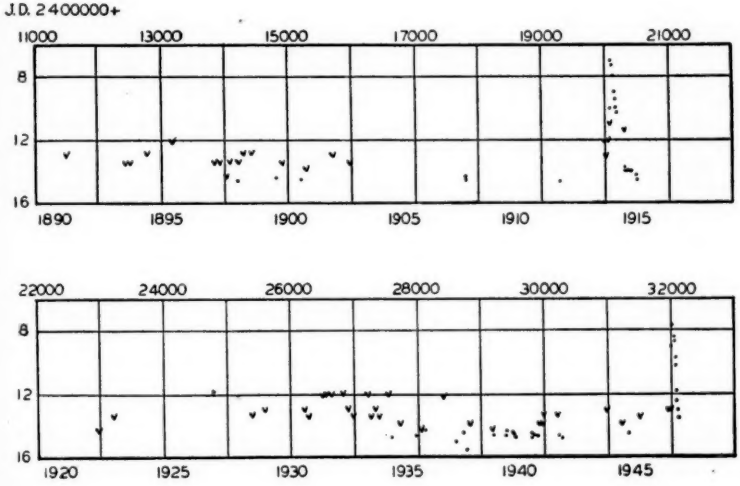
By LEON CAMPBELL, Recorder

Nova Sagittae, 1913: Delayed word from Dr. Kurt Himpel of Heidelberg, Germany, announces the second rise to maximum of Nova Sagittae, found by Miss Mackie at Harvard in 1913. Thus we have another recurrent nova to be added to the steadily increasing number of this class. Himpel found the nova increasing in brightness by 2.6 magnitudes on the night of June 28 over an interval of four hours; a very valuable observation at a very opportune time.

A search of Harvard Plates by Mrs. Mayall reveals that on one plate taken four hours later than Himpel's last visual observation, the nova appears as of the ninth magnitude, and subsequent plates indicate that the maximum was at-

tained on June 29, at photographic magnitude 7.7. Immediately the nova began to decrease steadily in brightness, and on August 15, 48 days after maximum, the photographic magnitude was recorded as 13.3.

Mrs. Mayall has re-measured the plates covering the history of the original 1913 outburst, and finds that maximum occurred on November 22, 1913, at photographic magnitude 7.0. The decrease to minimum on that occasion was not quite so rapid as the present one, requiring some 35 days to drop to magnitude 10.4. The faintest recorded minimum magnitude was 15.5 on September 1, 1919.



NOVA SAGITTAE NO. 2
1913, 1946

The list of recurrent novae now includes T Coronae Borealis with two outbursts (1866, 1946), RS Ophiuchi with two (1898, 1933), T Pyxidis with four (1890, 1902, 1920, 1945), Nova Sagittae with two (1913, 1946), Nova Sagittari with two (1901, 1919), and U Scorpii with three (1863, 1906, 1936). This group forms an interesting class, perhaps a connecting link between the SS Cygni-type stars and normal novae. It may well be that other so-called normal novae, especially those with light curves closely resembling those of the already recognized recurrent novae, may later prove to be of this same class.

It is interesting to note that two of these recurrent novae were found during their second outburst while they were rising to maximum, RS Ophiuchi by Loreta in 1933, and now Nova Sagittae by Himpel in 1946.

Double Period Variable: Reverend Daniel O'Connell of the Riverview College Observatory reports that the variable 192.1937 Carinae, CPD —63°1126, $9^h\ 23^m\ 57^s$, —63° 5′ (1875), is a variable of the double period type; a short period of 67.5 days superimposed on a long period of about 1500 days. The photographic

range in brightness is from 7.8 to 9.7, the star being brighter visually than photographically.

Nova T Coronae Borealis (155526): This star has apparently passed its recent secondary maximum brightness and has begun its slow decline to minimum, which, if we are to judge by its previous action, will require several years to reach.

AG Pegasi (214612): Mr. Joseph Ashbrook calls attention to the peculiar variable AG Pegasi, which has a very unusual spectrum closely related to those of the nova-like variables Z Andromedae and P Cygni. The visual amplitude of AG Pegasi is 6.2 to 9.4, according to Zinner. From 1937 to 1943 the star seems to have been nearly constant at magnitude 8.0, but a recent rise of about half a magnitude has been reported in *Circular* 154 of the Société Astronomique de France.

Observations of brightness are very desirable, for the recent activity of this star may herald a sudden outburst.

AG Pegasi, which is 6^m7 east and $3^\circ1$ north of ϵ Pegasi is now conveniently located for observation. Positions and visual magnitudes of comparison stars are:

Star	R.A. (1900)	Dec.	Magnitude
17 Pegasi	$21^h\,52^m1$	$+11^\circ\,36'$	5.6
BD$+10^\circ$ 4604	37^m7	$+10^\circ\,22'$	6.0
$+13^\circ$ 4781	42^m0	$+13^\circ\,15'$	6.6
$+10^\circ$ 4645	47^m0	$+10^\circ\,39'$	6.9
$+11^\circ$ 4677	46^m8	$+11^\circ\,33'$	7.6
$+10^\circ$ 4638	45^m2	$+10^\circ\,20'$	7.8
$+10^\circ$ 4643	46^m4	$+10^\circ\,26'$	8.5
$+10^\circ$ 4637	44^m8	$+10^\circ\,15'$	9.3
AG Pegasi	$21^h\,46^m0$	$+12^\circ\,29'$	var

Observations received during July and August: The receipt of nearly 6,000 observations during each of the months of July and August marks a decided renewal of variable star activity since the war years. A thousand of the observations submitted by C. Chassapis, of Athens, Greece, during July, represents his observations of nine variables covering the years 1936-1944. The observations received in August reflect the excellent observing conditions which prevailed over many sections of the country. A total of 11,781 observations—5,792 in July and 5,989 in August—were contributed by 72 observers, as listed herewith:

	July—1946—August					July—1946—August			
Observer	No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.	No. Var.	No. Ests.
Ahnert	16	313	29	170	Dafter	9	46	9	26
Ashbrook	3	11	..	..	Elias	6	7	33	115
Ball	..	..	32	53	Fernald	210	376	215	558
Bappu, M. K.	35	96	..	..	Flower	5	28	4	12
Bappu, M. K. V.	50	188	..	..	Focas	18	22	76	165
Battle	10	11	..	..	Ford	..	..	8	8
Blunck	70	96	55	68	Garneau	20	21	12	13
Bogard	4	8	..	..	Gossner	5	48	..	..
Boone	24	24	8	8	Greenley	4	5	8	8
Bouton	6	6	7	7	Guimont	..	..	12	15
Buckstaff	29	79	23	116	Halbach	14	14	17	21
Chandra	..	..	45	50	Hare	5	25	15	90
Chassapis	100	1,611	132	533	Harris	25	25	34	34
Cilley	32	100	23	50	Hartmann	121	140	115	126
Cousins	..	..	31	33	Holloway	8	16	16	36

Observer	July—1946—August No. Var.	No. Ests.	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.	No. Var.	No. Ests.
Holt	93	152	110	164	Plakidis	26	60	28	99
Howarth	15	16	15	15	Raphael	..	..	12	106
Hukill	3	32	2	39	Reeves	..	..	3	5
Itzigsohn	44	68	50	276	Renner	55	63	52	52
Kearons	..	..	11	11	Robinson, H.	9	9	..	..
Kelley	2	5	4	7	Robinson, J. C.	..	..	30	45
Kelly	11	11	13	13	Rosebrugh	11	87	10	121
Kitley	41	94	38	87	Schoenke	10	10	9	15
Knott	3	3	1	1	Segers	15	21	13	25
de Kock	94	413	88	396	Sill	..	..	65	65
Koons	31	50	61	81	Stahr	24	30	10	11
Ledbetter	38	49	41	48	Swaelen	..	..	3	9
Luft	23	291	25	571	Treadwell	..	..	6	6
Mallett	42	61	19	24	Upjohn	4	15	9	12
Meek	..	..	29	121	Wade	5	21	3	11
Nadeau	59	95	100	170	Webb	24	27	15	18
Oheim	67	109	109	128	Weber	40	40	..	..
Oravec	42	130	33	92	Welker	17	24	25	38
Parks	18	36	19	37	Weller	8	23	12	33
Peltier	140	223	162	293	Zirin	42	56	47	124
Petzold, H. E.	6	6	..	..					
Petzold, H. R.	40	146	45	205	72 Totals		5,792		5,989

September 16, 1946.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Speculations Regarding Ethereal Sound From Bolides

There is often reported a curious phenomenon associated with the appearance of a bolide that is most puzzling to students of meteoritics. Observers have claimed that they had heard a hissing or swishing sound simultaneously with the appearance of a bolide. There are hundreds of such reports, many made by observers at great distances. Obviously the ordinary sound effect could not be an explanation and in years past it has been generally assumed that such reports were a problem in psychology. In recent years some scientists have been inclined to grant the truth of this phenomenon despite its controversial nature and the seeming lack of a scientific basis for such an effect.

This shows a dissatisfaction with the psychological explanation. Certainly there are many good and careful observations which tend to show that it is something more than psychology that is involved, especially where observers state that their attention was attracted to the bolide by their having heard the sound first and the general agreement as to the sort of sound heard. It might be said that it is good psychology itself for the mind to accept the "handy" psychological explanation of a phenomenon that seems to defy common sense. Its application by some astronomers to the phenomenon in question is itself a theoretical carrying over of some principles of psychology to a different set of assumptions since associations between sight and sound are yet to be proved in the laboratory and

there are no examples of such in everyday experience. It may be just as good psychology to say that the reason the sound is not more generally noted is that being a weak transient sound it is subdued in the consciousness by the powerful visual stimulus of an awe-inspiring bolide. Observers find it difficult to recall all the phenomena of a bolide especially after a few days, and a comparatively weak phenomenon as an ethereal sound would be the first to suffer, especially when its probable impossibility is pointed out to them.

In the light of present knowledge we are forced to speculation and, though the suggestions briefly outlined herein are highly speculative, the writer believes that they have enough scientific background to show that a physical solution is not impossible and to excite the interest of others toward venturing into the study of this phenomenon along theoretical and experimental lines, a research which will undoubtedly result in new knowledge.

It may be interesting to show first, that our sense of hearing is extremely acute and sensitive, for an air displacement of less than a ten thousand millionth part of an inch is sufficient to produce hearing. This is only about a hundredth part of a molecule. Since the sound occurring simultaneously with the appearance of a bolide could not be a direct propagation of sound waves from it, we can assume that the sound is a secondary effect resulting from some other cause. As an example, if we give our imaginations free rein we can imagine that the bolide in its flight generates "ray particles" akin to cosmic rays or the solar P radiation.* Such "ray particles" would travel at enormous speeds ionizing the atmosphere through which they passed and, depending on meteorological conditions, water vapor would condense upon these ionized atoms in a manner somewhat analogous to the Wilson cloud chamber. The sudden condensations of water vapor would create sound waves. This is but one way such "ray particles" could cause sound though it is admitted that such a "ray particle" hypothesis is perhaps the least probable.

The second speculation is not to be regarded so lightly. It is the one held most likely by authorities, notably Professor H. H. Nininger (see *C.S.R.M.*, **2**, 79-81; *P. A.*, **47**, 97-9, 1939), one of the first to propose it and also the term "ethaërial sound." It is that the bolide generates streams of powerful radio energy. This energy upon reaching the ground is conducted through various objects, in which if circumstances are favorable, rectification of the wave takes place. The resulting direct current with the hissing modulation originating in the flight of the bolide causes the object to vibrate reproducing the hiss audibly. Such an effect is well known among radio engineers. All sorts of objects have reacted as radio receivers among them are steam radiators, stoves, pots of boiling water, refrigerators, water faucets, safety razors when in use, tin fences, and automobiles, to mention a few. In general it can be said that the boundary or contact effect between materials causes rectification of the radio energy. There can hardly be any doubt that the circumstances of the flight of a bolide through the atmosphere can result in the generation of powerful radio and electric currents. We already know that meteor static can be picked up on a sensitive receiver and in one instance a number of persons felt a distinct electric shock as a meteorite passed and fell nearby. The writer is of the opinion that most of this radio energy lies in the microwave region, that is in the centimeter and millimeter bands since an ionized gas, such as a bolide leaves, produces oscillations in that region.

*Cf. *P. A.*, **50**, 187 (1942).

Speculating further, heat waves and perhaps energy in the millimeter region can cause sound. When we think of heat we generally lose sight of the fact that incredibly small changes in the amount of heat can produce effects. Anyone who has read of Alexander G. Bell's experiments with the thermophone and spectrophone which use such an effect, cannot but marvel at the beauty and sensitiveness of the experiments. Bell succeeded in transmitting sound over a considerable distance by means of a beam of heat rays. He proved that sonorousness is a property of all matter when it is under the influence of a fluctuating beam of heat. One of the best materials is lampblack and in one experiment some lampblack in a Helmholtz resonator produced a volume of sound audible to an audience of several hundred. Since most of the energy of a bolide is in that heat region of the spectrum we have a possible explanation for the sound on this principle. Temperatures of bolides are estimated at one hundred thousand to a million degrees. Fluctuations in this heat could be inherent in the production of it by the flight of the bolide or it could be modulated in passing through the varying and chaotic conditions of the atmosphere surrounding the bolide. Upon reaching the earth such energy could cause sonorousness in any sort of object including vegetation. Perhaps such energy impinging on the ear itself could induce vibrations in the skin, foreign material or in the tiny hairs within the auditory passage. Similarly, if streams of energy in the microwave region are produced by the bolide, such energy would induce heat in material that it struck to produce sound on the principle just discussed.

Another speculation is that the sound may be due to a hitherto unsuspected physiological effect of the centimeter and little-known millimeter radio energy. That is, that such radio energy could be rectified in the ear mechanism itself. An inspection of diagrams of the anatomy of the ear shows many places where this could take place at the contacts between the hammer, anvil, and the stirrup, for instance. One could remark on the similarities between the anatomy of the ear and microwave "plumbing." We know of internal ear noises caused by illness and other physiological causes and perhaps microwaves can produce them also. The fact that electric currents can cause a sound in the ear was established almost one hundred and fifty years ago when Volta and Ritter experimenting on the physiological effects of galvanic currents discovered that when a feeble current was passed through the ears, musical sounds were heard.

This does not exhaust the possible effects that could cause a sound simultaneously with the appearance of a bolide. We may mention one other in passing. The bolide together with its tremendous envelope and shock wave forms one plate of an enormous condenser of which the other plate is the earth. Fluctuations in the electrical charges of the "bolide plate" as it moves would react on the air delectric to cause the air to emit sounds.

Bizarre as some of the speculations may see, the writer believes that in the present state of our knowledge the question is open for discussion and not until all the possibilities are considered can we start to hold definite opinions.

VINCENT ANYZESKI.

400 Lombard St., New Haven, Conn.

Origin of Lunar Craters

There are at present two main theories as to the origin of the lunar craters. Of these two, most people seem to favor the meteoric bombardment theory.

Although I do not wish to discard this theory completely, I am rather skeptical of it. I will try not to repeat the arguments which have been stated time and again. There is one point, however, which I haven't seen brought out and I think is important.

The craters were necessarily formed after the moon had solidified. Since the moon is in that state now, why haven't any craters been formed recently? It is said that meteors are less abundant now than a billion years ago, but I don't think the difference, if any, is that great. Also it seems improbable that at least a few large meteors would not have hit the moon in the last two centuries or so.

On the other hand, if the craters were of volcanic origin, there wouldn't be any new craters formed since all volcanic activity is thought to have ceased long ago.

This idea doesn't prove or disprove anything for certain, but I believe it is an argument against the meteoric theory.

TOM SWIHART.

2120 Broadmoor, Elkhart, Indiana.

General Notes

Dr. John A. Russell (A.B., 1935, University of California, Los Angeles; M.A., 1937, and Ph.D., 1943, University of California, Berkeley) has been appointed, as of date September 1, 1946, to the position of Assistant Professor and Head of the Department of Astronomy of the University of Southern California.

Dr. A. Pannekoek has retired as Director of the Astronomical Institute at Amsterdam, and has been succeeded by Dr. H. Zanstra, appointed professor of astronomy at the University of Amsterdam. Dr. Pannekoek's present address is Zeist; Regentesselaan 8, Holland.

Colonel Dinsmore Alter is on terminal leave after more than four years service in the Transportation Corps of the Army, and has returned to his duties as Director of the Griffith Observatory in Los Angeles. During these years Colonel Alter traveled approximately 250,000 miles on the ocean as a Transport Commander, visiting each continent except the Antarctic.

Dr. Bernard Lyot, astronomer at the Paris Observatory and member of the French Academy of Sciences, showed some results of his photographic observations on Pic du Midi, in the library of the Mount Wilson Observatory at 813 Santa Barbara Street, Pasadena, California, on Wednesday evening, August 14, 1946. The pictures included planetary and lunar photographs and motion pictures of solar phenomena. The meeting was attended by members of the staff of the Mount Wilson Observatory and of other scientific institutions in Southern California.

Note on Chinese Loess

In a note in *Popular Astronomy* in 1931, I suggested a possible meteoritic origin of loess. While in China (1932-45), I made researches on the subject, including a microscopic study of loess particles that revealed evidence of about one per cent of the loess grains having sharp spines or ridges inconsistent with

the eolian theory of the origin of loess though they could be explained if the material had originated from the sun during gigantic solar eruptions.

In the library of the Royal Asiatic Society at Shanghai I found a report on the Yellow River, published by Fijnje van Salverda in 1891, in which report he stated that there are angular stony fragments in the loess formation evidently not rounded by the action of water, generally found in heaps together and forming stone-agglomerates whose dispersal is always more or less limited. If the presence of these stones is not due either to the action of wind or water, it would be of interest to examine them to see if by any chance they are of meteoritic origin.

JOHN B. PENNISTON.

New York City, N. Y.

Lord Tennyson's Interest in Astronomy*

Farringford, less than a mile from Freshwater, the Isle of Wight home of Lord Tennyson which was purchased in September, 1944, by British Holiday Estates Ltd., has been turned into an exclusive guest house which will cater for not more than twenty-five guests.

The poet was very fond of composing in the Summerhouse which looks southward over Maiden's Croft, and this was decorated by him with his own hand with paintings, most of which have unfortunately been destroyed owing to the decomposition of the plaster. He had the platform on the roof constructed in order that he might study the stars, as he was greatly interested in astronomy. His bedroom and that of his wife were on the north side of the first floor. It was his custom after dinner to have dessert laid in the small room next to the conservatory and he would adjourn there and drink his port, afterwards adjourning to the drawing room, or to his library to smoke and compose.

*With the Compliments of Travel News Service, Queens House, Leicester Square, W.C. 2.

Resumption of the Astronomischer Jahresbericht

At a meeting of astronomers from thirteen countries in Copenhagen in March, in connection with a special meeting of the Executive Committee of the International Astronomical Union, it was agreed that we should encourage the German astronomers to continue the publication of the *Astronomischer Jahresbericht*. Sir Harold Spencer-Jones, President of the International Astronomical Union, has recently been in Heidelberg in conference with Professor A. Kopff, and has assisted in the partial restoration of the Rechen-Institut. Working with the American military authorities, he has assisted in the provision of five rooms in a university building for Professor Kopff and his staff. The Astronomer Royal writes: "I discussed with Professor Kopff the question of the continuation of the preparation of the *Astronomischer Jahresbericht*. Professor Kopff is prepared to continue this work, which is of such importance to all astronomers, provided that the astronomical literature can be made available to him. It seems to me, that with the present difficulties in communication with Germany, the best arrangement would be for all literature to be sent to me here (Royal Observatory, Greenwich), clearly marked 'For the Rechen-Institut,' and I will forward it to Professor Kopff through the British Naval authorities.

"The last published volume of the *Jahresbericht* appeared in 1943, and referred to the literature for 1941, but, because of difficulties of communication

during the war, much of the 1941 literature is not covered in this volume. It is desirable, therefore, that all runs of astronomical journals, publications of observatories, or separate reprints of astronomical articles from journals that are not primarily astronomical, should go back to the time when they ceased to be accessible to the Germans."

The American authorities in Heidelberg understand the importance of this work to the astronomers of America and will try to see to it that paper for the publication is made available.

I suggest that shipments of publications be made promptly, either directly to the Royal Observatory, Greenwich, or through the exchange service of the Smithsonian Institution in Washington.

HARLOW SHAPLEY, *Chairman*,
American Section, International Astronomical Union.

A High School Planetarium

A planetarium for school use, the first of its kind in this country, has just been presented to the Central High School of Philadelphia by Mrs. Franklin Spencer Edmonds, in honor of her late husband who was a well-known Philadelphia lawyer, a State Senator, and an alumnus and former professor of history at the school.

The planetarium will be constructed in the new high school building at Ogontz and Olney Avenues during the summer months and will be dedicated this fall. It will be known as "The Franklin Spencer Edmonds Planetarium" and will be housed in a dome 21 feet in diameter in a specially designed room in the basement of the school. This room will be large enough to accommodate a usual astronomy class.

Until the removal of the Central High School to its new location in 1939 this institution, founded in 1836 and one of the oldest high schools in this country, always pioneered in the teaching of astronomy. It was preceded only by Yale (1830), Williams and Wesleyan (1836), Western Reserve and Harvard (1838). The Central High Observatory, under the direction of Professor E. Otis Kendall of the high school faculty, early achieved an international reputation. This early observatory furnished 430 moon culminations, about 120 occultations of stars together with numerous observations of comets, especially the great comet of 1843.

When the school moved in 1854 from its original site, now the location of John Wanamaker's Store, to the southeast corner of Broad and Green Streets, great care was given to the construction of a second roof-top observatory and the school's activity in astronomical teaching and research increased. A graduate of the school in this period, Charles T. Yerkes, endowed the Yerkes Observatory at the University of Chicago. Another graduate, George Davidson, became associated with the U. S. Coast Survey and was directly instrumental in persuading James Lick to leave money for the establishment of the famous Lick Observatory on Mt. Hamilton in California.

Among the teachers of the school who distinguished themselves in the field of astronomical research was Professor Kendall, who resigned from the high school faculty and became in 1892 the Director of the newly established Flower Observatory at the University of Pennsylvania. In 1873 Professor Monroe B. Snyder started a notable career in astronomical research which lasted until his

retirement in 1920. Associated with him was Elihu Thomson who, in addition to the many outstanding contributions he made in science, conducted numerous studies in astronomy while a member of the high school faculty. Professor Thomson devised a method of making astronomical mirrors, now standard among amateur as well as professional astronomers, and wrote numerous papers on lunar craters, the origin of zodiacal light, the aurora, meteors, and comets.

Other distinguished graduates of the school in the astronomical field included Jesse Pawling who taught physics at the school, later became an instructor at the University of Pennsylvania, and finally joined the staff of the U. S. Naval Observatory; Dr. Paul R. Heyl, now associated with the U. S. Bureau of Standards, who in recent years was awarded the Potts Medal by the Franklin Institute for his famous redetermination of the Constant of Gravitation.

When the Central High School's new building on the southwest corner of Broad and Green Streets was opened in 1900 still another roof-top observatory was included with a newly acquired 15-inch refracting telescope and a smaller 8-inch telescope. In 1905 this observatory was destroyed by fire and the larger telescope ruined. However, Professor Snyder continued his researches and read many papers on astronomical subjects before the American Philosophical Society.

Franklin Spencer Edmonds, who died on October 29, 1945, was graduated in 1891 in the 96th Class of Central High School, and was also a graduate of the University of Pennsylvania. He early interested himself in politics and was associated with many reform movements during his lifetime. In addition to other books he was the author of a history of the Central High School.

During a trip to Canada last Fall to address the Provincial Association of Protestant Teachers of Quebec, Dr. Cornog, President of Central High School, was shown the planetarium used there in the High School of Montreal. He suggested to Mrs. Edmonds that such an instrument would be a fitting memorial to her husband who took a keen interest in Central High's achievements in astronomy and in all the educational affairs of the School. A special fireproof dome will be erected to house the planetarium in accordance with local fire regulations.

Philadelphia, Pa., July 21.

The Day of the Week Corresponding to a Given Date

In the April issue (p. 206) of this year we published a note under the above title by Mr. Wolfgang Schocken, 25 Ramban St., Jerusalem, Palestine. Unfortunately, a number of errors were introduced into that note and, consequently, we give here a corrected form of the process involved, we hope this time without error.

The following notation is used.

W = number of day of week, Sunday being 1, Monday 2, Tuesday 3, etc.

M = number of the month of the year, January being 1, February 2, etc.

D = day of month.

B = number of year in Gregorian Calendar.

Now if:

(1) $(M+9)$ divided by 12 leaves a remainder m,

(2) $(7M+10)$ divided by 12 leaves a remainder μ,

(3) B divided by 100 gives a quotient Q and a remainder R [Note: if $m \geqslant 10$ replace B by $B-1$ in (3)],

(4) Q divided by 4 leaves a remainder χ,

(5) R divided by 4 leaves a remainder ρ,

(6) $w = D + 2m + 4\mu + 5x + 3R + 5\rho + 3$, then w divided by 7 will leave the remainder W.

In a later letter Mr. Schocken commented upon the new Russian calendar, which was adopted in 1923, as follows:

"In my opinion the calendar system recently adopted by the U.S.S.R. is the calendar of the future. According to it all years, other than centennial years, divisible by 4 are leap years of 366 days. Centennial years, however, are common years of 365 days, except those which, when divided by 9, leave a remainder of 2 or 6. This calendar will have an excess of one day only after 56,842 years, whereas the Julian calendar shows an equal discrepancy after 128 years and the Gregorian calendar, after 3,378 years."

Light Sources Compared

The 1,000-watt incandescent projection lamp for home movies is the mightiest man-made concentrated light source, producing 32,000 candlepower of light for each square inch of filament surface compared with 1,300 candlepower per inch for a 40-watt light bulb. John H. Kurlander, Westinghouse lamp engineer, points out that the sun is tops in light efficiency, producing for each square inch of its surface a two million candlepower wallop of light above the earth's atmosphere and half as much at sea level, after the rays have filtered through upper air layers.

A single 100-watt incandescent lamp produces as much light as 129 full-size candles topping a giant birthday cake, Westinghouse engineers say. Each candle produces 12½ lumens, the engineer's yardstick for light quantity, as compared with 1,620 lumens for the electric light bulb.

Book Reviews

Geology Applied to Selenology, by J. E. Spurr. (Scientific Press Printing Company, Lancaster, Pennsylvania. $5.00.)

The moon is almost of greater importance to geologists than to astronomers. Indeed, there is no better preparation for a study of the moon than a knowledge of the earth; and I could point to many common and current errors concerning the moon and Mars that are due chiefly to ignorance of geology. The erring ones don't know how a planet works; and the earth is the planet easiest to reach and study.

A master geologist wrote this book; and having contributed to the theory of geology with notable success, J. E. Spurr has applied to the moon, the same keen observation and scrupulous logic that made him a good interpreter of the earth.

The book is divided into two parts, respectively titled,

I The Imbrian Plain Region of the Moon
II The Features of the Moon.

Part I appeared in 1945 as a separate volume. The author casts out at once the "meteorite" theory of lunar craters, and interprets them as volcanoes. Gilbert saw in the great depth of lunar craters, an evidence of impact; and compared them to the known meteor-craters of the earth. But Spurr ascribes their depth to

subsidence of a lava-column relieved of its gases; and cites the great subsidence-hollows or "calderas" of the earth as kindred structures. I submit that the author here encounters a difficulty which he does not solve: the spine which towers in many lunar craters is single and central; while the "Wizard Island" craters in our earth's calderas—I borrow the name from Crater Lake, Oregon, and use it generically—are rarely central and never spine-shaped; and I have seen as many as eight in calderas which I have studied.

The wreath-shaped mountains that rim the moon's craters are multiple in some cases, single in others. Gilbert saw in the multiple wreaths a major contrast with the earth's volcanoes; Spurr interprets them as due to slips and faults along interweaving fissures caused by down-dragging of the subsiding lava-column.

In his study of the Imbrian region, Professor Spurr has demonstrated many types of structures: wrinkles due to compression of the mare-lavas while still plastic; faults, generally later than the wrinkles; swellings, or domes due to inflation by gases released under thick lava flows, and others too numerous to cite in a brief review. Best of all, Professor Spurr infers a long history of changes for each area of the moon, just as a geologist would infer the history of each unit area of the earth. The state of the moon's face, at any given stage of its development, could be reconstructed by means of his studies, even as we could picture the paleography of the earth.

He warns his readers that there was never a halt in crater-outbreak, from the time when the thin first crust formed to the close of all activity. Hence, the periods of the moon's history "are not sharply distinct, but pass by transition into others."

A review cannot attempt to be a summary; and must be unjust to a book so crammed with facts and inferences as this one. The book is written for astronomers and geologists, but it is a challenge to the intelligent lay reader, who must read earnestly to get its message; but the message is a large reward for his effort.

FREDERICK K. MORRIS.
222 Charles River Road, Cambridge, Massachusetts.

What are Cosmic Rays? By Pierre Auger. (The University of Chicago Press, Illinois. $2.00.)

This volume by a widely recognized investigator of cosmic rays represents a thorough revision of an earlier volume by the same author. The scope of the work is clearly outlined in two paragraphs taken from the translator's preface.

"This book is written primarily for the reader who lacks a technical knowledge of physics but who wants to keep in touch with current developments in science. It is not intended for the specialist but should provide a good perspective for the physicist who wants to get a quick view of what has been done in this new field. It is as simple and straightforward as the nature of the subject and the vast amount of material available will permit.

"It is the only volume in English which gives a broad and up-to-date discussion of all the major cosmic-ray phenomena. The treatment of its topics is, in general, nonmathematical and is designed both to provide the background and to describe the outstanding developments in the field. The author first introduces the reader to the modern techniques which enable the physicist to detect sub-

atomic particles. The story of cosmic rays is then traced from the time of their discovery to the most recent stratospheric balloon flights. The author recounts the various problems which have confronted the investigators of cosmic rays and describes how they went about solving them. He does not neglect to point out the main problems which are yet unsolved."

The volume consists of 120 pages, an extensive index, and 22 pages of plates. The reading is not particularly easy because of the newness of the field investigated. However, a reader of average intelligence will obtain some ideas relative to this very recent cosmological development. C.H.G.

The Universe Around Us. By Sir James Jeans. (The Macmillan Company, N. Y. $3.75.)

The present volume is one of the fourth edition of a work by this title. The name of the author is well known on both sides of the Atlantic as that of an expert in dealing in a simple way with abstruse subjects. The tenor of the volume is indicated quite clearly in the author's final paragraph, which we quote because of its beautiful phraseology and its tremendous scope in thought.

"Looked at in terms of space, the message of astronomy is at best one of melancholy grandeur and oppressive vastness. Looked at in terms of time, it becomes one of almost endless possibility and hope. As inhabitants of a civilized earth, we are living at the very beginning of time. We have come into being in the fresh glory of the dawn, and a day of almost unthinkable length stretches before us with unimaginable opportunities for accomplishment. Our descendants of far-off ages, looking down this long vista of time from the other end, will see our present age as the misty morning of the world's history; they will see our contemporaries of today as dim heroic figures who fought their way through jungles of ignorance, error and superstition to discover truth, to learn how to harness the forces of nature, and to make a world worthy for mankind to live in. We are still too much engulfed in the greyness of this world of ours to be able to imagine, even vaguely, how this world of ours will appear to those who will come after us and see it in the full light of day. But by what light we have, we seem to discern that the main message of astronomy is one of hope to the race and of responsibility to the individual—of responsibility because we are drawing plans and laying foundations for a longer future than we can well imagine." C.H.G.

Solar Traffic

The Sun sits in the center
And all the stars and things
Just circle round and round him
Upon their private rings.
Up to date there's never been
A wreck of any kind
But just the same I think that we
Should bear it well in mind
That anything might happen
If in a careless mood
He should switch the current off
And we should come unglued.

—Mabel George Haig.

535 E. Hadley St.,
Whittier, California.